A NEW TECHNIQUE TO DETERMINE UPGRADING PRIORITIES FOR LOW TRAFFIC VOLUME ROADS

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ABSTRACT: *Where traffic volumes are very low - less than 25 per day - conventional measurement of benefits from road upgrading is inappropriate. The new technique described here ascribes priority for upgrading the different road sections within a region using weighted proxy values for identified principle road uses. For example, population serves as a proxy for the fulfilment of the social needs of residents served by a given road section. Essentially subjective judgements about the relative importance of various road uses are applied in a consistent and objective manner to rank roads which compete for a fixed volume of funds.*

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INTRODUCTION

This paper describes a method of assigning relative priorities to road upgrading projects competing for a fixed volume of funds. It is applicable to roads carrying low traffic volumes for which the traditional appraisal methods are inappropriate. The method was developed for the Northern Territory Department of Transport and Works by the consulting firm Pak-Poy & Kneebone Pty. Ltd., and applied to roads in Central Australia in a report submitted to the Department in January 1982: "Central Australia Road Development Strategy Stage II".

The same method has since been applied to roads in the Katherine and Tennant Creek area, and appears to be readily adaptable to other areas and other conditions. Examples given in this paper all relate to the Central Australian case.

THE PROBLEM

Traditional methods of valuing the benefits accruing from road improvements, which emphasize reduced vehicle operating costs and reduced road user costs, are not appropriate to roads with very low traffic volumes. The threshold for using such methods is at least 25 vehicles per day (vpd). In Central Australia traffic volumes of fewer than 20 vpd are common.

In such areas road upgrading is undertaken not for the purpose of reducing vehicle operating costs or road user costs but in order to improve basic access for isolated communities. This is especially true in areas which are flood prone and where existing roads do not provide year round access. The difference between a road which is passable for 11 months of the year, and that unpredictably, and one which is passable for 12 months of the year is very great in such areas.

The importance of assured access lies chiefly in an isolated community's need for:-

- access to medical services;
- access to social and recreational amenities found in urban centres;
- tourism;
- inward transport of consumption goods, agricultural inputs etc.;
- outward transportation of livestock, agricultural products, etc.

In the case of livestock particularly, the cost of impassability and of poor road condition can be high both in terms of damage and loss of condition in transit and in terms of animal suffering.

The problem, then, is to find an objective and consistent means of applying essentially subjective judgements about the relative merits of different road sections. Should a road which serves a small resident population but many tourists be given a higher priority than one which serves several settlements but has no significance for tourism? What weight should be given to freight traffic vis-a-vis human traffic? How should the unquantifiable benefit of improved access be set against the all-too-quantifiable cost of upgrading?

THE SOLUTION

The method we have developed rests on the presumption that a fixed volume of funds exists for road upgrading. The purpose of evaluation is, therefore, not to compare costs and benefits of each possible upgrading project and test them against a threshold net present value (NPV), internal rate of return (IRR) or benefit/cost ratio. It is to rank all the possible upgrading projects so that the first to the nth project may be selected for implementation, the nth project being that which exhausts the funds available.

The first step in applying the method is to determine the relevant categories of road use in the area under study. The next step is to assign to each category of road use a quantifiable proxy to indicate each road section's relative importance with respect to that category of road use. In the case of the Central Australian study the following road uses and proxies were adopted:-

Road Use	Quantifiable Proxy
Social needs	Population served
Tourist access	Tourist numbers annually
Cattle transport	Cattle turn-off annually
Goods distribution	Tonneage of goods (other than cattle) produced by and distributed to the population served.

The base year value of each proxy for each road section is then ascertained or estimated from available data and projected forward for, say, ten years. Those projected proxy values then represent a stream of benefits accruing from each road section, which can be reduced to an NPV in the conventional manner - conventional, that is, except that it is expressed not in dollars but in numbers of people, cattle or tonnes of goods. The hypothetical example of a road section from Warradoola to Tenacity Creek, which follows, clarifies the procedure.

It might be objected that a stream of benefits already exists because the road section exists, even without upgrading. Those benefits will be enhanced by upgrading, however, and there is an implicit assumption that the benefits of upgrading are proportional to the existing benefits of the road without upgrading.

There are costs to be taken into account as well. The capital cost of upgrading plus the difference between maintenance costs before and after upgrading are similarly reduced to a net present value.

WARRADOOLA-TENACITY CREEK : BENEFITS OF UPGRADING

		Pop'n No.	Tourists No.p.a.	Cattle No.p.a.	Goods t.p.a.
Base Year :	1982	500	6,000	10,000	4,000
Projected :	1983	510	6,180	10,100	4,080
	1984	520	6,365	10,201	4,162
	1985	531	6,556	10,303	4,245
	1986	541	6,753	10.406	4,330
	1987	552	6,956	10,510	4,416
	1988	563	7,164	10,615	4,505
	1989	574	7,379	10,721	4,595
	1990	586	7,601	10,829	4,687
	1991	598	7,829	10,937	4,780
	1992	609	8,063	11,046	4,876
NPV in Base Year, Discounted at 10% p.a.		3,879	48,541	74,429	31,032

WARRADOOLA-TENACITY CREEK : COSTS OF UPGRADING

		Without Upgrading $/km	With Upgrading $/km	Difference $/km
Base Year :	1982	900	30,000	29,100
Projected :	1983	900	1,250	350
	1984	900	1,250	350
	1985	900	1,250	350
	1986	900	1,250	350
	1987	900	1,250	350
	1988	900	1,250	350
	1989	900	1,250	350
	1990	900	1,250	350
	1991	900	1,250	350
	1992	900	1,250	350
NPV in Base Year, Discounted at 10% p.a.				31,250

The upgrading cost is estimated on the basis of the "end state" of the road - a concept discussed below.

At this stage we have for each road section a number of NPV figures expressed in different units: residents, tourists, cattle, tonnes and dollars. In order to arrive at an aggregate it is necessary to assign weights to the various proxy values. These weights are in effect exchange rates to convert them all to a common currency. The weight assigned to each proxy is indicative of the relevant importance of the benefits associated with each use category.

DETERMINATION OF WEIGHTS

There is no theoretical basis for the determination of these weights, or exchange rates. In our Central Australian analysis we used the following guidelines to assign relative weights to the benefit proxies:-

- The social needs of each resident should carry more weight than the benefit associated with one tourist annually.
- The social needs of one resident should also carry more weight than the average tonneage of goods produced by and distributed to one resident.
- Cattle should be weighted more than in proportion to their value as goods - on the grounds that cattle are more vulnerable to damage and loss if road conditions are bad or if communications are cut altogether and, for humane reasons, they are entitled to consideration other than as merchandise.

These guidelines were then formalized by estimating the number of trips made annually per unit of benefit proxy, and applying a "comfort factor". The comfort factor simply recognizes that the comfort of people is a higher priority than that of cattle, which in turn is a higher priority than that of goods. Comfort, in this context, embraces reduced driver stress, passenger comfort, time savings, reduced bruising of cattle and reduced damage to goods through vibration and, in the case of perishable goods, excessive journey times. The results of this exercise may be be summarized as follows:-

Benefit Proxy	Trips Annually	Comfort Factor	Trips x CF
Population	19.4	2	38.8
Tourists p.a.	2*	2	4
Cattle p.a.	1	1.5	1.5
Goods, t.p.a.	1	1	1

* In and out on a route.

The figures have been normalized so that the weight applicable to the social needs proxy ("S" for convenience) is 1. Rounded to two decimal places the following weights were adopted:-

Benefit Proxy	Weight	
	Name	Value
Population	S	1
Tourists p.a.	T	0.10
Cattle p.a.	C	0.04
Goods, t.p.a.	G	0.02

In other words, the benefits of road improvement associated with the annual social needs of 1 resident are equal to the benefits associated with 10 tourists, 25 cattle or 50 tonnes of goods.

The choice of 1 tonne as the unit for goods is quite arbitrary, but it happens to meet the criterion set out in our broad guidelines, that cattle should be weighted somewhat more than in proportion to their value as goods: at the time of our Central Australian Study one animal was worth between $300 and $400 on average, compared with $400/t for petroleum and between $500/t and $1,000/t for most non-bulk goods.

These values would not be applicable to all areas of course; but it should reassure other analysts who use this method to know that we found it quite easy to reach a concensus.

The same approach was not helpful in determining the weight to be applied to the cost of upgrading, to offset the aggregate benefit. Instead, we examined several roads which had recently been upgraded and computed the weight which would have had to be applied to the cost of that upgrading in order to achieve a small positive net benefit. Our reasoning in adopting this procedure was that actual decisions to upgrade were the best guide to the Government's perception of priorities, and that any such upgrading must have been judged to yield benefits which exceeded costs.

The result of this analysis was the assignment of a value of 0.2 to weight "N", applicable to the net cost of upgrading - capital costs plus maintenance costs or minus maintenance savings - per km.

Cost per km is the unit of measurement here, rather than total cost for the road section. It can readily be accepted that the benefits of stress reduction and time savings will be proportional to the length of road involved. Such a relationship is by no means necessary in the case of all-year access, however: a flooded creek crossing has the same effect whether it lies on a 100 km road section or a 1 km road section. But if it is accepted that the probability of a road section being cut is proportional to its length, then the problem disappears and all benefits may be taken as varying in proportion to road section length, and the values assigned to the benefit proxies are all implicitly on a per kilometre basis. For consistency, net costs must be expressed in $/km too.

RANKING

Finally, each road section was ranked according to a composite index value I, computed as follows:-

$$I = S(\text{population}) + T(\text{tourists p.a.}) + C(\text{cattle p.a.}) + G(\text{tonnes of goods p.a.}) - N(\text{net cost of upgrading}) + X.$$

"X" was an undefined value which could be added optionally if the analyst believed that there was a significant factor which was not taken into account in the selected proxies. It was agreed that X should be zero unless:-

- a road section is particularly vulnerable to flooding;
- aboriginal or other disadvantaged communities are served;
- there is some identifiable reason to expect the upgrading in question to affect to an unusual degree the development potential of the area served.

In other areas it may be expected that a wide variety of grounds might exist to assigning a value other than zero to X - such as military importance or the enhancement of linkages in a wider transport network.

In our hypothetical Warradoola-Tenacity Creek example, a total index value of 6,081 results:-

$$I = 1(3,879) + 0.10(48,541) + 0.04(74,429) + 0.02(31,032) - 0.2(31,250) + 0 = 6,081.$$

The absolute index values which result from this procedure have no meaning in themselves. They can be large or small, positive or negative. Their only significance lies in the rank order which they establish.

END-STATE CONCEPT

In order to estimate upgrading costs it is obviously necessary to know the level to which upgrading is to take place.

Roads making up a regional road system serve a variety of needs. Some can be classed as single purpose facilities (e.g., property access), others cater for a range of functions. It is possible, therefore, to identify a road hierarchy for the region similar in concept to that generally accepted in the urban environment. Effectively the regional road hierarchy would be based on the level and type of social and economic function performed by each link in the network.

The identification of a regional road hierarchy is important as it is then possible to define in quantitative terms the expected "end state" for the various elements in the road hierarchy.

The expected "end state" definition for each road need not necessarily be achievable in the short or medium term. Nevertheless, the ultimate standards accepted for each part of the system provide a guide to the suitability of existing parameters such as location, general alignment, reservation width and dedication of the land in meeting the perceived end state requirements.

For example, it may be quite sufficient and cost effective to accept the existing conditions for a road where its function and the volume of traffic are not expected to change in the future. On the other hand, a decision on partial or full relocation or widening of the existing road reserve may be indicated if the present alignment is unsuited to the perceived requirements or is deficient at certain locations. This would avoid continual investment in an existing but ultimately unsatisfactory alignment.

The definition of the end state conditions and related ultimate standards for each link, therefore, is central to the development of the model.

Given that the end state conditions are known for each link, the purpose of the model then is to determine the priorities for upgrading with the objective of meeting the planned ultimate conditions for the network.

A detailed costing exercise was undertaken and it was found that the capital cost of progressive upgrading was significantly higher than the cost of upgrading directly to a section's end state. Where the end state is sealed, there may be maintenance cost savings which make immediate full upgrading additionally attractive.

WHAT ABOUT CONVENTIONAL BENEFITS?

As described here the new technique ignores the conventional benefits of reduced vehicle operating costs and road user costs. In the Central Australian case they were found to be trivial in comparison with the benefits of enhanced basic access, and indeed with the cost of upgrading, and so were omitted.

There is no reason, however, why these benefits should not be added to the others we have mentioned. They would be expressed in dollars and assigned a weight. This weight might be the same as that assigned to net upgrading costs, since these are also expressed in dollars. But it would be logically acceptable to assign a different weight on the grounds (for example) that the public dollars on the cost side of the equation are not the same as the private dollars on the benefit side.

LIMITATIONS OF THE NEW TECHNIQUE

It cannot be claimed that the technique described is perfect. The chief limitations are:-

- that it does not provide for differentiation between degrees of road improvement in respect of benefits;
- that it depends upon the analyst's ability to determine the nature and extent of upgrading appropriate to each road section, for costing purposes;
- that factors specific to a given road section, such as exceptional economic development potential or social priorities, are accommodated only by the rather nebulous "X" factor;
- that it may not be valid to apply uniform weights across a non-homogeneous region.

These were not found to be significant drawbacks in the Central Australian case, but if the technique were applied in other regions the analysts might need to address themselves to overcoming some or all of these limitations.

CONCLUSION

In spite of its limitations we believe the technique described more closely models the actual determinants of upgrading priorities for low traffic volume roads than conventional analytical methods. While it cannot be said to make objective and quantifiable those things which are essentially subjective and unquantifiable, it nevertheless permits an objective and above all consistent application of subjective judgements to a range of road sections fulfilling very different purposes. And while it does not address the question, "Is it economically justified to expend public money to upgrade road section A?", it does provide a means of placing road section A either above or below road sections B,C and D in a list of priorities.

For these reasons we advocate its use, with adaptation to region-specific conditions and needs, in other areas where traffic volumes are low and where basic access is the objective rather than reduction of vehicle operating and road user costs.

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