



## Valuing externalities of Bangkok's mass transit (Skytrain) system

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### Abstract

The Bangkok Transit System (BTS) is a 23.5 kilometre elevated heavy rail system in the central area of Bangkok that was opened in 1999. The electrified system was implemented by a private company as a Build Transfer Operate project. No explicit subsidies are provided to the company. Patronage on the system upon opening was only about a quarter of that forecast, but has since climbed steadily. Recent patronage has been about 280,000 trips per weekday, which is a little under half of that originally forecast and is a little over 60 percent of its currently estimated patronage potential.

The system has provided significant benefits for its users and the community. Door-to-door travel time for many people using the system is about half of that by former transport modes. About 36 percent of trips on the BTS are generated demand resulting from the improved accessibility that it offers. Of the BTS passengers who previously used road-based transport, 34 percent used car or taxi – this resulted, initially at least, in a reduction in traffic on the roads of about a fifth. The environmental benefit resulting from the reduction in road traffic is substantial. The diversion of former road-based trip to the BTS released road capacity that allowed additional travel to be generated with associated increased emissions and also with economic and social benefits to the community.

The paper outlines the features and travel demand impacts of the BTS, and describes an evaluation that quantified the external benefits of the BTS to road users and to the community at large. The evaluation gave specific consideration to the effect of generated road traffic on these benefits.

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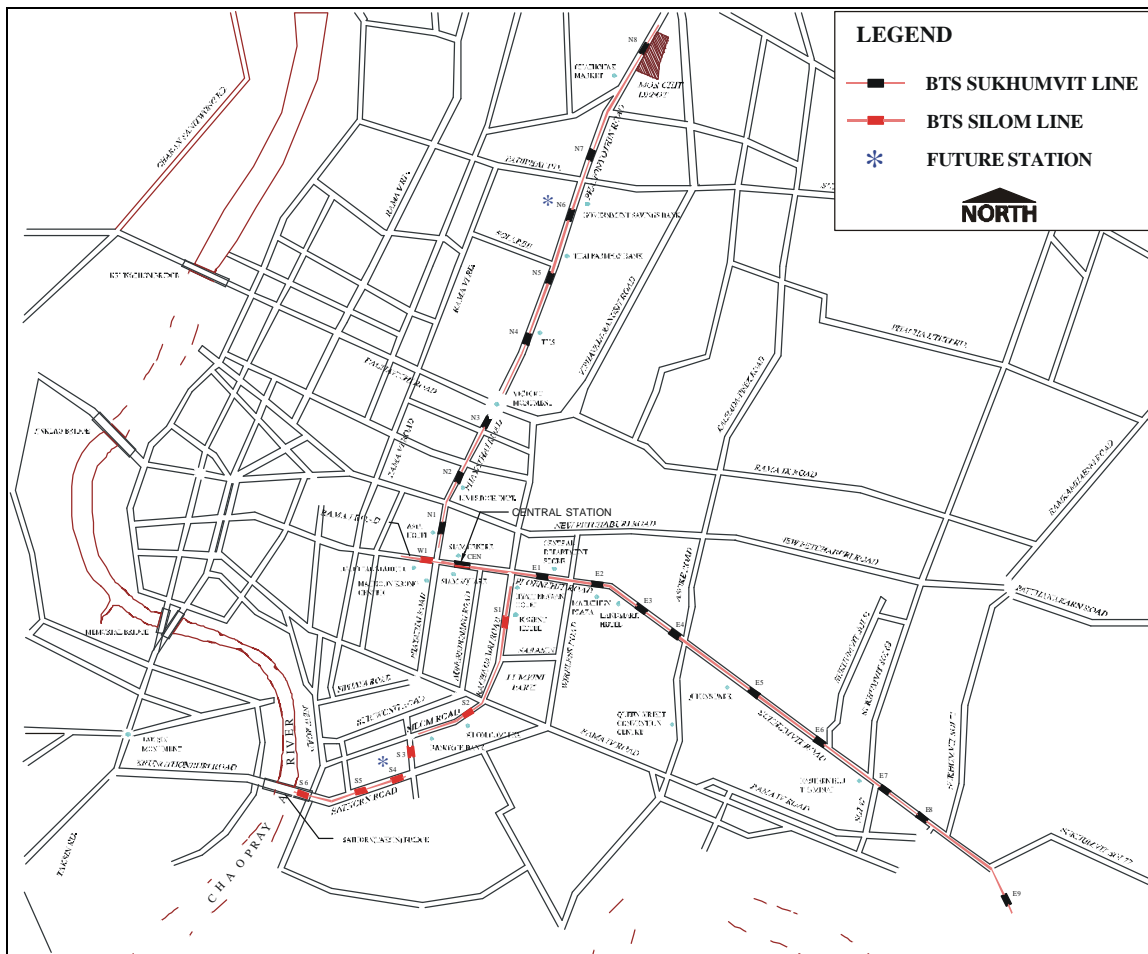
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## Introduction

Bangkok is a city of 11.4 million people. Its economy grew faster than national average growth in real gross domestic product of 8.1 percent per annum over the 15 year period before the financial crisis in 1997. In response to world-renowned congestion and private sector prompting, a number of privately financed road and public transport projects were initiated in the late 1980s and early 1990s. Amongst these was the Bangkok Transit System (BTS – also known as Skytrain).

The BTS is an elevated heavy rail mass rapid transit (MRT) system that was implemented by the Bangkok Mass Transit System Public Company Limited (commonly referred to as the Bangkok Transit System Corporation). The BTS, which was officially opened in December, 1999, consists of two fully elevated lines with total length of 23.5 km and 23 stations. It traverses some of Bangkok's busiest streets and activity centres (see Figure 1).

**Figure 1** BTS System



Source: Bangkok Transit System Corporation (see also <http://www.bts.co.th/e-inforoutes.html>)

The BTS was initiated by the Bangkok Metropolitan Administration in 1990. In 1992, it signed a contract with the Bangkok Transit System Corporation to deliver the project through a Build Transfer Operate arrangement with a separate operating concession.

Two other privately financed rail systems were initiated in Bangkok at about the same time. A 20 km, 19 station underground heavy rail line (the "Blue Line" – the BTS is also known as the "Green Line") is well progressed, and will open in 2004. The other is a failed elevated heavy rail ("Red Line") and expressway system – while the Thai Government is hoping to revive this scheme, little progress has been made to date. It is notable that the three projects were initiated by three separate government agencies (the Bangkok Metropolitan Administration, the Mass Rapid Transit Authority and the State Railways of Thailand respectively). A high level Office of the Commission for the Management of Land Transport was subsequently established in the Prime Minister's Office to ensure that the separate systems were developed within an integrated Mass Rapid Transit Master Plan. Nevertheless, at present there is likely to be only limited integration between the BTS and the Blue Line, with integration of these lines with other transport modes also being imperfect.

While the quality of the BTS and its services is high, patronage attracted by the system has lagged expectations. In 2001, the International Finance Corporation (which is a member of the World Bank Group, and a part financier of the project) commissioned a short study to assess the extent of the external impacts (ie the effects of the BTS on non-users) and to identify means to enhance the performance of the BTS (PAS/EPS 2001). This paper describes the derivation of the external benefits of the BTS.

### **BTS Service Provision and Patronage**

BTS is a high quality MRT system that compares very favourably with similar MRTs recently developed in other cities in the region in terms of the quality of construction, rolling stock and services. Its cost of A\$2.5 billion is consistent with other MRT systems developed in Asia in recent years. BTS services are provided at intervals of between three and five minutes throughout its 18 hours of daily service.

In common with other recently developed MRT systems in the region (with the exception of those in Singapore and Hong Kong where supportive public transport policies, restraints on car use and land use provide a markedly different context to that in Bangkok), patronage on the BTS has lagged expectations. Demand was 220,000 passengers per weekday in mid-2001. In mid-2002, patronage had risen to about 280,000 passengers per day, which is a little under half of the original forecast demand of 600,000 trips per weekday. Issues that contributed to this underperformance include:

- BTS was developed on a stand alone basis and is intended to recover its costs through the fare box – as a result, BTS' fares are significantly higher than those of buses, which have lower costs and which are also

subsidised. BTS fares, relative to income, are similar to those for MRT systems in Kuala Lumpur (Malaysia) and Manila (Philippines), but are much more expensive than in richer Singapore and Hong Kong (where fares relative to income are respectively about 20 and 30 percent of that for the BTS);

- while lifts were initially installed at five stations and escalators at a few key stations, passengers are required to use stairs for access between streets and the BTS at most stations (with stations being equivalent to three-storeys above street level) - this is being remedied by the installation of escalators at more stations;
- BTS is not well integrated with the bus system – bus routes have not been modified to complement BTS because it appears that the Bangkok Mass Transit Authority, the State Enterprise monopoly bus operator that does not operate on a commercial basis, has no incentive to make any adjustments;
- the fare system for BTS and bus services independent, which inhibits intermodal travel;
- Government social policy to restrain bus and taxi fares increases the gap between BTS fares and the cost of other modes, thus further constraining BTS patronage – it is notable that this policy also hurts the bus and taxi industry by limiting their profitability and, in turn, the quality of their fleet and services;
- BTS is not well integrated with adjacent land use due to the lack of a sound development control process;
- the Asian financial crisis, which commenced in mid-1997, reduced household income and resulted in a decline in the population of Bangkok; and
- high BTS fares (the BTS fare for a typical trip of 6 kilometres of Baht 18<sup>1</sup> compared with Baht 10 a similar journey by air-conditioned bus and Baht 5 for non-air-conditioned bus) requires a structural change in personal expenditure that contributes to the gradualness of changes in travel patterns and BTS patronage growth, especially when account is taken of the effect of the financial crisis on most potential BTS passengers.

Given income and population for Bangkok at the time of the study for the International Finance Corporation, it was estimated that patronage could reach about 400,000 to 500,000 passengers per weekday when patronage ramp-up (ie the transition process to a new equilibrium with the BTS in place) is complete.

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<sup>11</sup> In June 2001, A\$1.00 = Baht 24 = US\$0.53

Surveys of 1,300 BTS users undertaken for the International Finance Corporation study in May 2001 showed that 64 percent of BTS passengers interviewed formerly made the same or a similar trip before the BTS was opened. The remaining 36 percent were new trips – some of which were previously made between other origins and destinations, and some were newly generated (see Figure 2).

The three factors that had influenced interviewees' use of BTS, in order of priority, were the reduced travel time it offered (ranked first by a considerable margin – reflecting travel times that declined by up to 50 percent), its comfort, and its reliability. When asked to rank the three main factors that had caused them not to use the BTS, bus passengers travelling in the BTS corridors indicated that the BTS network was not convenient to them, its cost was high, and pedestrian access to the BTS was difficult. These bus passengers indicated that the three main factors that would encourage them to switch to the BTS were extension of the BTS network, a reduction in fares and improved bus feeder services.

The surveys indicated that average household income of BTS users was about 50 percent higher than average households in Bangkok, with about 75 percent of users coming from households that had higher-than-average income. This situation is reinforced by reported data that 75 percent of the BTS users interviewed came from households that had at least one car – which also indicates a willingness by car-owning households to use the BTS.

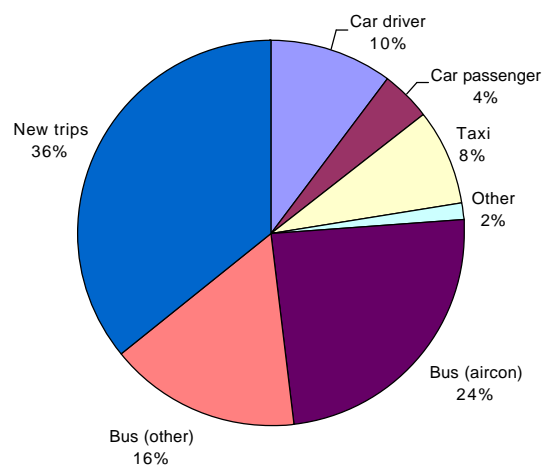
### BTS Impacts

It is self-evident that people who use the BTS have gained a benefit, for they would not use it if the value of doing so did not equal or exceed the costs that they incur. The extent of this benefit is reinforced by the quantity of newly generated travel on the BTS.

However, major developments such as the BTS can be expected to also have impacts on people who do not use the system. The objective of the study that is reported in part in this paper was to comment on, and quantify where possible, these external impacts, which include:

- impact on remaining users of roads, who are affected by the transfer of some road users to the BTS and from changed traffic and pedestrian management on roads along which the BTS is located;

Figure 2 Source of BTS patronage



Source: PAS/EPS (2001)

- the environmental and social benefits that the community at large gains from the transfer of some people to the BTS;
- effects on property and business; and
- other impacts such as visual intrusion and community severance.

#### *Impacts on Road Users*

Road users have been affected through the impact of BTS infrastructure on road capacity, restrictions on road-based pedestrian movement and reduced road traffic as some people transferred from road-based transport to the BTS.

The columns on which the BTS track and stations is placed are mostly (but not always) located in the median of roadways, and hence impact the traffic capacity of the roads along which the BTS is situated. However, the effect is minor, with traffic-carrying capacity of the roads being reduced by only about 1 percent. However, the level of policing of bus lanes on the roads declined, and more non-bus traffic now uses the bus lanes. Thus, the overall traffic movement capacity of the roads has been maintained, though probably at the cost of slower and more variable bus travel time.

Construction of the BTS included a more distinct median on which fencing was installed to prevent pedestrian access across the heavily trafficked roads along which the BTS is located. Pedestrian movement across the roads now occurs primarily at road intersections or via pedestrian overpasses (where stairs to stations can also be used to cross roads). Thus, the BTS reduced the number of locations where pedestrians could cross the roads (which increases their walk time), but has separated pedestrian to a substantial degree from traffic movement (which reduces the risk of accidents).

The detrimental effect on pedestrians of the space required for stairs to the elevated stations has been more substantial. Stairs to stations typically occupy half of the width of footpaths, and sometimes leave only 1-2 metres for pedestrian movement along the footpaths.

Road traffic in the BTS corridors will have been reduced where BTS users previously were car drivers, taxi passengers (assuming that the taxis shifted to other locations or were withdrawn from service) or were bus passengers (if the buses were withdrawn – which did not actually occur). The reduction in traffic reduces congestion, and hence provides a benefit to continuing users of the road system through lower vehicle operating costs and faster travel time. Had it occurred, withdrawal of bus services would have resulted in a disbenefit to continuing bus passengers because of the lower frequency of service.

The decline in road traffic will be offset by generated road traffic resulting from people taking advantage of the released road capacity to undertake travel that previously has been suppressed. If generated traffic replaced all of the reduction in traffic made possible by the diversion of passengers to the BTS, the

people who continue to use the road system will face the same traffic congestion that occurred prior to the BTS, and hence gain no benefit. However, the people who make new trips still gain a benefit from their travel.

#### *Air Pollution*

The principal environmental benefit of the BTS is reduced air pollution resulting from the transfer of former road users to the BTS. Recent research (Lvovsky et al 2000) concludes that, in developing and emerging countries, the cost of local pollution is large compared with that from related global emissions. Hence, the study focused on local emissions. These savings are maximised if no additional traffic is generated in response to the transfer of people from road-based transport to the BTS. If all released road capacity is absorbed by generated traffic, emissions from road-based transport return to the same level that existed prior to the BTS, albeit with a higher level of travel demand accommodated for the same level of pollution. Work undertaken on air quality in Bangkok (Parsons 2000) indicated that particulate emissions from poorly maintained, low technology, diesel fuelled commercial vehicles, and buses in particular, were a major concern and had a substantial impact on people with activities in the vicinity of major roads.

Production of electricity used by the BTS will result in some additional pollution. However, the amount of electricity consumed is small (0.15 MW/day, compared with current installed capacity of 4,218 MW in or near the Bangkok Metropolitan region). Moreover, most power is generated by high stack power stations that use natural gas and which are located outside the most heavily built-up part of Bangkok.

#### *Property and Business*

It was not possible to directly link the BTS to a rise in rents and property values. However, industry comment suggested that:

- the presence of the BTS could not in itself address the underlying weakness in the property market in Bangkok;
- however, the improved accessibility and image provided to properties near the BTS is an effective point of differentiation that makes it easier to lease the properties, which in turn also increases their value;
- buildings near the BTS command higher unit rentals and better overall yields due to low vacancy rates; and
- the BTS may be a decisive factor in decisions to undertake future developments, as appears to be the case with some property redevelopment that has begun to occur.

It seems likely that the last effect will become stronger as the property market recovers, and as factors such as property value and accessibility have a greater

bearing on decisions than has occurred in the past when other factors such as contacts and finance sometimes influenced the location of property developments. There is the potential for improved property taxation and development controls to encourage property development in the vicinity of the BTS that allows more effective use to be made of the BTS.

Increases in property values in the vicinity of the BTS may have been offset to some extent by declines in the value of property in less accessible locations. However, data was not available to demonstrate this effect. It is likely that there has been a net increase in the value of property due to the capture by property owners of some of the consumer surplus gained by BTS users and others.

### *Social*

The extent of the generated patronage on the BTS reflects an enhanced quality of urban life made possible by the improved accessibility offered by the system, with the additional patronage representing people participating in new social and business activities. Previously suppressed road travel, which can now occur because the diversion of some people from car, taxi and bus to the BTS released road capacity, provides further community benefits.

Only about a quarter of users of the BTS come from households with income below the average for all households in Bangkok. It is therefore evident that regular travel by the BTS is generally unaffordable to people with low income. This is due to the high cost of BTS fares, including the up-front cash cost of stored value cards that offer travel at discounted fares. Nevertheless, lower income groups will still have benefited from the facility, though:

- health benefits from reduced emissions from motor vehicles – these benefits accrue particularly to people who have activities along roads, which is likely to include a disproportionate share of poorer people involved in activities such as vending and local transport;
- reduced congestion, which reduces bus travel time for remaining bus users; and
- a generally improved urban environment and improved economic efficiency, which should improve the sustainability of economic growth and hence employment growth also.

Conversely, there would have been an opportunity cost to the poor if the investment required for the BTS came at the cost of reduced investment that might have more directly focussed on alleviating poverty and supporting employment growth for the poor. However, funding for the BTS mostly came from commercial finance generated on the basis of the merits of the facility, and cannot be presumed to have been at the cost of other investment in Bangkok.



### *Other*

Other potential external impacts of the BTS include the visual intrusion of the elevated system, severance and noise. While there had been some community concern with resonance of traffic noise under stations (with station structures covering most of the width of roads), this was not a continuing concern. The elevation of the BTS avoided community severance that would occur with an at-grade facility. The commercial nature of land use along the BTS routes and the substantial traffic noise that already existed meant that noise impacts were not serious.

### **Quantifying External Impacts of the BTS**

Following the above discussion, and taking account of data limitations, the value of the BTS to those who do not use it was quantified on the basis of changes in:

- vehicle operating costs for remaining road traffic;
- the value of personal travel time for occupants of remaining road vehicles;
- waiting time for remaining bus users, based on an assumption that bus frequency would eventually be reduced in response to the diversion of former bus passengers to the BTS;
- the benefit gained by generated road travel; and
- the benefit from reduced local air pollution.

Rises in property values is a manifestation of some of the benefits gained by BTS users and generated road trips that are transferred to land owners through the willingness of these travellers to make greater use of the property developments involved. In this manner, higher property value is an externality of the BTS as the benefit ultimately accrues to non-users of the BTS. However, it is an incomplete measure of benefits, it is difficult to use without risking double-counting of benefits, and data to support its use was inadequate. Hence, the benefit of increased land value was excluded from the analysis.

Similarly, the value of accident savings (due to a lower accident rate for travel by BTS compared with road vehicles) is not an externality of the BTS, but is a benefit that accrues to BTS users (and may have been presumed to have influenced their decisions to use the BTS). It, too, was thus excluded from the analysis.

The valuation of external benefits of the BTS included in the analysis is described in following sub-sections. In calculating the external benefits, consideration was first given two boundary conditions: (i) the situation in which no additional road traffic was generated in response to the reduced traffic congestion that resulted when some road users transferred to the BTS; and (ii) the situation where past traffic congestion suppressed sufficient road travel

demand that, when road users transferred to the BTS, all released road space was continuously absorbed by newly-generated road vehicle trips. Consideration was then given to intermediate cases.

The principal analysis was based on a conservative saturation BTS patronage of 300,000 passengers per day (to be reached in 2003), with a sensitivity test of the effect of potential patronage of 450,000 passengers per day (the mid-point of the range of estimated prospective patronage) also prepared in addition to other sensitivity tests. The results of the analysis are reported in Table 2 and Figure 3.

### Continuing Road Vehicle Users

Benefits to continuing road users following the introduction of the BTS result from reduced travel time and vehicle operating costs attributable to lower traffic congestion. It was estimated that the diversion of road users to the BTS, in the absence of generation of additional road traffic, resulted in an average 30 percent reduction in traffic volume on the roads along which the BTS is located, with a consequent 80 percent rise in average travel speed from the 17 kph that would have occurred with a continuation of almost fully saturated traffic flow in the absence of the diversion. Low average personal income of travellers resulted in the ensuing decline in the value of travel time being small compared with the reduction in vehicle operating costs.

The benefit to remaining road users declines if generated travel occurs because of the generated traffic increases traffic congestion. If all vacated road space is filled with generated travel, the benefit to the continuing road users evaporates because road travel conditions return to the level that would have prevailed without the BTS.

Data limitations made it necessary in the study to assume that all diversion from road to BTS occurred for travel along the roads on which the BTS is located. Benefits to road traffic on links accessing the BTS were ignored as it is likely that most BTS passengers would still have used motorised transport for this section of their journey.

It is possible that some reduction in traffic flow due to the transfer would also have occurred on roads other than those on which the BTS is located, for example on parallel roads. Given a fully saturated road network, this would result in a larger benefit to remaining road users because the decline in traffic volume on all affected roads would occur at a higher level of saturation and hence result in greater increases in travel speed for remaining road traffic. In this respect, it is therefore likely that the analysis was somewhat conservative, and benefits to remaining road traffic could be larger than estimated.

The analysis also assumed that the transfer of former car drivers to the BTS would result in their cars remaining un-used, ie with no replacement trips being made. It is possible, though, that other household members might use the cars for other trips. If the trips were made in the BTS corridors, the effect of the travel

will be taken into account within the current analysis through the valuation of the benefit to generated trips. If the trips were made in other congested locations, it seems likely that there would be a net social loss due to the marginal cost of the generated travel being higher than its benefit. It is expected that such effects will temper but not change substantially the results of the analysis reported in this paper.

The diversion of bus passengers to the BTS resulted in a decline of almost a quarter in bus patronage on the roads along which the BTS was located. The loss to continuing bus users of a corresponding reduction in the frequency of bus services, if it were to occur, would be modest because of a low average value of time and a still high service frequency (with up to 160 buses per hour on some sections of road).

#### Local Air Pollution

In the absence of generation of new road travel, it was estimated that the diversion of road users to the BTS would reduce vehicle use by 116 million vehicle-kilometres per year (given BTS patronage of 300,000 trips per weekday). A rapid assessment methodology was used to determine the economic value of reduced local emissions resulting from this decline (Lvovsky et al 2000). The method estimated the decline in ambient levels of particulate matter, SO<sub>2</sub> and NO<sub>x</sub> based on emission generation rates for vehicles in Bangkok, the decline in vehicle use estimated to have occurred as a result of the diversion of road users to public transport, and the economic cost of health (mortality and morbidity) and non-health (visibility, soiling and corrosion) effects of these pollutants.

The benefit estimated to occur in the absence of any generation of road trips was Baht 174 million (A\$7.3 million) – see Table 1. The decline in particulate matter accounted for 68 percent of the benefit, and reduced SO<sub>2</sub> for a further 26 percent. While reduced bus use accounted for only 5 percent of the decline in vehicle-kilometres of travel, the poor quality and low technology level of diesel-fuelled buses resulted in their withdrawal accounting for 80 percent of the quantified benefit of reduced local air pollution.

Generation of road traffic in response to the diversion of former car users to the BTS would increase emission of pollutants from the above level, and thus reduce the external benefit of reduced pollution. If all vacated road space was re-occupied, emissions would return to their former level, and there would be no environmental benefit.

**Table 1 Saving in vehicle emissions with no generation of additional road traffic**

	Mode			Economic cost of damage (Baht million/year)
	Car and Taxi	Bus	Total	
Decrease in vehicle use (million vehicle-km)	110	6	116	
Decrease in emissions (tonnes/year)				
PM	1	11	12	118
NO <sub>x</sub>	147	170	318	46
SO <sub>2</sub>	18	3	22	10
Economic cost of damage	35	139	174	

Source: PAS/EPS (2001)

### Generated Road Travel

The average benefit for each generated road trip was valued, conventionally, at half the unit benefit that was gained by remaining road users in the absence of generated trips, ie assuming a demand curve that was linear for the range of demand under consideration. The benefit gained by generated trips rises from zero when no generation occurs to a maximum when generated trips fill all road space vacated by former road users who transferred to the BTS. To the extent that the demand curve might be non-linear given the substantial range of demand being considered, this could slightly over-state the benefit to generated trips.

### Summary

The present value of the benefits for the two boundary conditions were estimated at (see Table 2):

- Baht 18.3 billion (A\$760 million) in the absence of generated road travel demand; and
- Baht 2.5 billion (A\$104 million) if generated travel fully uses space vacated by people who transfer from road vehicles to the BTS.

**Table 2 External Benefit of the BTS for Two Boundary Conditions  
(Baht million, March 2001 prices)**

	Condition 1: Without generated traffic				Net Benefit	Condition 2: With generated traffic filling all released road capacity <sup>(2)</sup> Consumer surplus for generated trips
	Reduced vehicle operating costs to remaining road traffic	Reduced travel time for remaining road traffic	Loss to bus users from reduced service frequency	Reduced environmental damage		
Best Estimate:						
2001	645	54	7	115	807	120
2003	886	82	10	174	1,132	164
Present Value <sup>(1)</sup>	13,439	1,595	187	3,412	18,259	2,489
Sensitivity Test (Present Value):						
• Reduced diversion from car	12,909	1,568	202	3,456	17,731	1,718
• No reduction in bus services	13,158	1,585	0	684	15,427	2,011
• 50% higher in BTS patronage	12,086	1,423	193	5,032	18,348	4,107

(1) Present value of benefits over 25 years with a 7% discount rate.

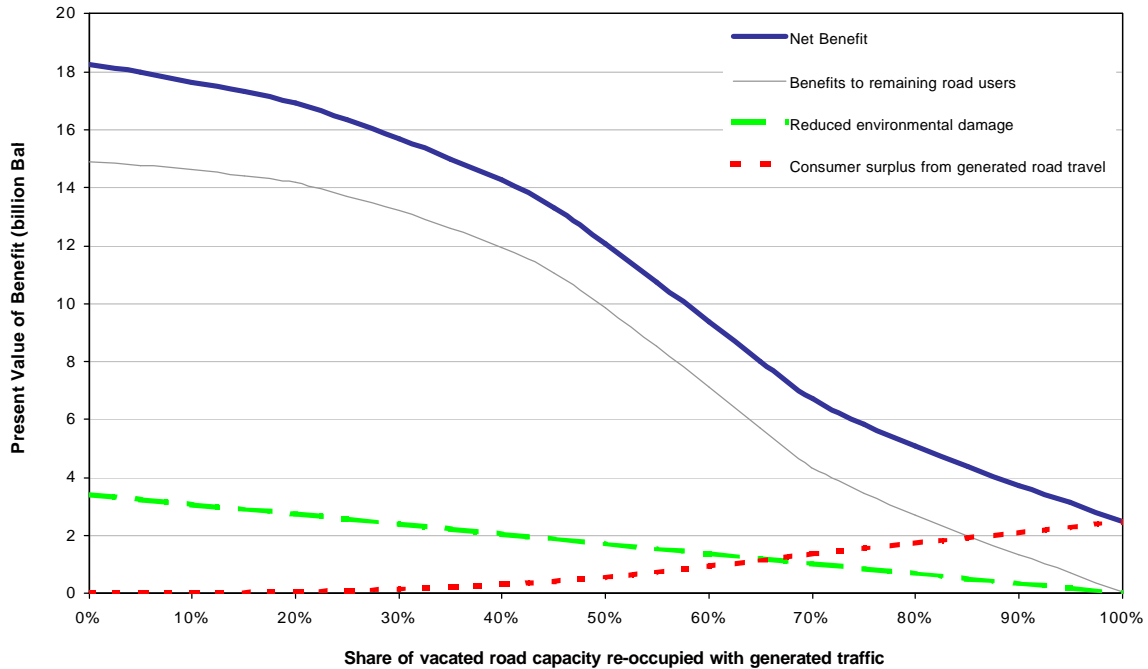
(2) When all released road capacity is filled with new vehicle trips, road travel conditions remain as they were without the BTS and so there are no savings in vehicle operating costs and travel time for continuing road traffic, etc.

Source: PAS/EPS (2001)

The present value of the external quantifiable benefits between the two boundary conditions is shown in Figure 3. Evident in this figure are:

- the benefit to road users who continue to use the road system is maximised when no additional road traffic is generated as the remaining road users gain the maximum benefit from reduced congestion;
- the unit benefit gained by the continuing road users declines as additional traffic is generated, whereas the generated traffic gains a smaller unit benefit, thereby reducing the overall benefit of the BTS to road users;
- the economic value of reduced local air pollution is maximised if there is no generated road travel (because the number of road vehicle trips is minimised in this situation), and declines to zero when generated road trips fill all space vacated by road users who transferred to the BTS (because total emissions return to the level that occurred before the BTS was opened) – nevertheless, the latter situation represents a case where more travel can occur without a increase in local air pollution; and
- the transition of external benefits between the two boundary conditions is not uniform because neither the relationship between traffic volume and speed, nor between vehicle operating costs and congestion, is linear.

**Figure 3 External Economic Benefits of the BTS**



Source: PAS/EPS (2001)

Sensitivity tests (see Table 2) indicate that:

- a lower level of diversion of former car drivers to the BTS than indicated in the surveys (ie assuming 6 percent of BTS users were previously car drivers rather than 10 percent as indicated in surveys undertaken during the study) has only a small effect on the benefit if there is no generated demand, but reduces the benefit by about 30 percent if generated traffic fills all released road capacity;
- the principal analysis assumed that bus services were reduced in proportion to the decline in bus patronage that occurred with introduction of the BTS – if this reduction in service did not occur, as has been the case in the past, there would be a lesser decline in road traffic, which would reduce the potential benefit to remaining road users, the environmental benefit and the benefit from generated road travel, but would avoid the loss that accrues to remaining bus users from a reduced frequency of service – the decline in environmental benefits is particularly severe because of the economic cost of particulate emissions from poorly maintained, diesel-fuelled vehicles; and
- the most significant effect of higher demand on the BTS (ie 450,000 passengers per weekday in 2003 and thereafter rather than 300,000) is to increase the benefit to generated road travel that can occur because of the greater amount of road capacity that is released with a higher diversion of existing road users to the BTS – notably, the benefit to remaining road users in the absence of additional road travel falls because the quantity of

traffic declines by more than the reduction in unit vehicle operating costs and travel time – by contrast, the environmental savings are greater because of the lesser quantity of continuing road traffic.

Adequate quantitative evidence was not available to precisely determine the extent to which generated demand has occurred in response to the diversion of road users to the BTS. Anecdotal comment was that the decline in traffic volume that might be attributed to the introduction of the BTS had been modest, ie there had been a substantial amount of traffic generation in response to the availability of road capacity. It was judged that generated traffic may have filled about 70-80% of road space vacated by trips that transferred to the BTS (leaving road traffic volumes with the BTS about 10 percent lower than was the case before the BTS was opened). This would result in a present value of quantified external impacts of the BTS of about Baht 6 billion (A\$250 million).

This outcome provides an indication of the economic consequences of sub-optimal road pricing. Road pricing in Thailand is similar to that in most places, with indirect taxation and charges for road use, but no charges that reflect the marginal cost of road use. Were such optimal pricing to occur, it is likely that more road users would transfer to the BTS and less road travel would be generated in response to the vacated road capacity. This would result in the BTS generating higher external benefits.

## **Conclusions**

The analysis of the external impact of the BTS indicated that:

- the columns on which the elevated BTS is located reduced the traffic-carrying capacity of the roads along which it is situated only marginally;
- the ease with which pedestrians were able to cross roads along which the BTS is located was reduced, but was made safer;
- the visual intrusion of the BTS was in part an aesthetic matter, but was not considered to be a major issue;
- community severance was not a significant issue due to the elevation of the BTS, with noise from the BTS also not a major issue given the commercial nature of land use along the BTS corridors;
- reduced local air pollution, especially particulate matter, is of particular benefit to people with activities along and near roads, which includes low income groups;
- the BTS has the potential to encourage and support increased densification of land use near the facility and hence to improve land use-transport efficiency;

- past suppression of road travel demand and sub-optimal road pricing resulted in significant generation of road traffic in response to the transfer of other road users to the BTS;
- the value of the BTS to continuing road users, people undertaking additional road travel and the community through reduced local air pollution was substantial, with the potential to be equal to about 30 percent of the capital cost of the project if there had been no generated road trips, but more probably equivalent to about 10 percent of its cost given the actual outcome; and
- sub-optimal road pricing results in more road travel demand than is optimal and imposes a substantial economic cost on the community by reducing the external benefit of the BTS.

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