FINAL REPORT

Evaluation of Wellington Trolleybus Replacement

Greater Wellington

March 2005

This document is confidential and is intended solely for the use and information of Greater Wellington
Our Ref: Z1395/REP/0718

Booz | Allen | Hamilton

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1 EXECUTIVE SUMMARY

1.1 Summary of Outcome

The evaluation concludes that the Efficiency Ratio of replacing the Trolley bus (TB) fleet is 1.1. In addition to this there are significant non-monetised benefits relating primarily to sustainability, the use of renewable fuel sources, improved reliability and mode shift from car. Conversely, reverting to diesel on the TB routes fails to meet a number of aspects of the NZTS.

1.2 Options Considered

Retaining the status quo is not an option in view of the age of the TB fleet; all the trolleybuses have covered more than 1 million km, well past the usual "retirement age" for diesel buses. If the TBs are scrapped then the diesel replacements could be in place within a year. However, a move to diesel would incur a one-off cost of around $700,000 to decommission the overhead wire network, which has also been included in the diesel bus costings. Refurbishing the TBs would be done at the rate of 15 per year over a period of 4 years. The option of hybrid vehicles was also examined.

Notice that it is not viable to reduce the number of TBs in the Wellington fleet as they currently operate on a defined set of cross-city routes that could not practically be reduced. Additionally, such a move would:

- Not reduce the overhead costs of the wire network in the CBD
- Reduce the number of TBs to the point where it is not economic to provide separate maintenance and other facilities.

1.3 Economic Case

For the **base case** (diesel), the present value of net costs over the 10-year evaluation period was found to be **$8.9m**. This assumes that all 61 TBs are replaced by diesels in year 0 and also takes account of the cost of removing the overhead wire network.

For the **TB option** the corresponding present value is **$18.3m**, assuming that the fleet is replaced over years 0 to 3. The additional subsidy required for TB relative to diesel is the scheme cost; this was found to have a PV of **$9.4m**.

In total the scheme benefits amount to $10.2m (PV) over 10 years, with air quality benefits comprising around 27% of the total.

1.4 NZTS Issues

The trolleybus option achieves a number of the objectives of the NZTS, particularly in relation to noise, greenhouse gas production, local air quality and the use of renewable energy. The diesel option fails to do this.

1.5 Passenger Growth

In the base case (diesel option), annual passenger growth of 2% has been assumed.

In 1998, research undertaken by Pinnacle Consulting indicated that passenger numbers would be less if the TBs were taken out of service and this was supported by overseas experience where a similar move had been made. Given the clear attractiveness to residents of an updated TB fleet, an annual growth rate in passenger numbers of 4% has been assumed for the TB option, reflecting factors such as improved reliability. However, this “ramps up” over 4 years reflecting the time taken to replace the TB fleet.

1.6 Reliability of Trolleybuses

It should be pointed out that many of the TB breakdowns occurring currently are not due to dewirements or other TB-specific factors; they are due to poor reliability as a result of a combination of the age of the vehicles and the fact that they are very intensively used. The average age of the diesel bus fleet is 8.5 years, compared to over 20 for the TBs; at this age a diesel bus would either be ‘retired’ or serving on school routes. New vehicles will, by their very nature, address the reliability issues but the new TB design includes a number of features specifically aimed at improving reliability.

1.7 Alternative Technologies

The technology for Hybrid Electric Vehicles (HEVs) is at a relatively early stage of development and does not yet appear to be at the point where it could be used for a significant part of the Wellington urban bus network without significant risks. The latter include reliability and performance, particularly in hilly terrain, and in maintenance requirements, given the complex technology used.

Based on experience elsewhere, the annual subsidy required for HEV operation was found to be almost 50% higher than the equivalent figure for TB; the 10-year present value is $26.5m for HEV compared to $18.3m for TB. In addition, HEV benefits will not be as great as for TBs because there are some emissions at the point of delivery.

The existing use of HEVs on two free city centre services in NZ is very different in nature from having an large network operating throughout Wellington. However, the argument is not that HEVs will not work in Wellington but that there are much higher risks associated with their use. The fact that they are operating elsewhere in NZ does little to allay these concerns, given the considerable differences. A web search on the subject indicates that worldwide experience has been, at best, mixed.

1.8 Energy Issues

In 2001, over 73% of the electricity used in NZ was from renewable sources such as hydro and geothermal. In Wellington this proportion will be higher as the general flow of electricity in NZ is from south to north. TBs therefore have the clear advantage that they are not dependent on imported, non-renewable fuel sources such as diesel. In terms of consumption, no electricity is generated in NZ from diesel so it is not possible to compare TBs with diesel buses in terms of their consumption per km operated.

2 INTRODUCTION

This report presents the findings of an evaluation study undertaken by Booz Allen Hamilton on behalf of Greater Wellington, the Regional Council (GW). The study was undertaken to provide a justification for the replacement of the existing fleet of trolleybuses (TBs) in order to secure funding from Transfund.

The current (February 2005) Transfund Allocation Process (TAP) has been used as the framework for the evaluation. In addition to economics this includes other aspects of the NZTS such as safety and sustainability.

The structure of this report is as follows:

- Chapter 2 discusses costs
- Chapter 3 describes the economic benefits
- Chapter 4 covers non-economic benefits
- Alternative technologies are examined in Chapter 5
- Conclusions are reached in Chapter 6.

The evaluation concludes that the Efficiency Ratio of replacing the TB fleet is 1.1. In addition to this there are significant non-monetised benefits relating primarily to sustainability, the use of renewable fuel sources, improved reliability and mode shift from car. Conversely, reverting to diesel on the TB routes fails to meet a number of aspects of the NZTS.

3 SCHEME COSTS

3.1 Basis of the Evaluation

For the evaluation, the base case has been taken as scrapping the existing TB fleet and replacing it with new diesel buses. The option case is to upgrade the TB fleet, continuing to use the existing motors and equipment but fitting new bodies which meet modern standards of comfort and accessibility, particularly for those who are mobility impaired. Experience elsewhere has shown that this is technically possible and that, because they have few moving parts, the electric motors in the existing TBs have a much longer life than the bodies. A hybrid electric option has also been considered. Notice that it is not a option to continue with the existing TB fleet in view of its age.

The evaluation has been undertaken over a 10-year period, which is the length of the proposed contract between Stagecoach and the Regional Council.

If the TBs are scrapped then the diesel replacements could be in place within a year. However, a move to diesel would incur a one-off cost of around $700,000 to decommission the overhead wire network, which has also been included in the diesel bus costings.

Refurbishing the TBs would be done at the rate of 15 per year over a period of 4 years. This has been taken into account in the economics.

Notice that it is not viable to reduce the number of TBs in the Wellington fleet as they currently operate on a defined set of cross-city routes that could not practically be reduced. Additionally, such a move would:

- Not reduce the overhead costs of the wire network in the CBD
- Reduce the number of TBs to the point where it is not economic to provide separate maintenance and other facilities.

3.2 Costing

A detailed costing has been undertaken with assistance from Stagecoach NZ, operator of the Wellington TB network.

The basis of the costing was as follows:

- Costed per km of operation: driver; diesel/power; carbons (TB only); tyres; RUC; insurance; maintenance
- Costed per vehicle: registration; ETM depreciation; vehicle depreciation (over a 16 year life) and capital charges; management; servicing
- Other items: ticketing; overheads (such as management, premises); and, for TBs only, maintenance of the overhead wire network.

All costs were compared with data from other Booz Allen sources and previous work and were found to be in the expected range. The costing has assumed that maintenance costs for new TBs will be lower than currently and also that the finance costs for the current TBs are effectively zero (as they are life-expired).

Profits were added to total costs on the basis of a fixed percentage of operating costs (excluding costs of the overhead wire network in the case of TBs). Revenue was then deducted to give a net cost or subsidy requirement for the diesel and TB options respectively. This was done for each year of the 10-year life of the proposed TB contract.

In recent years there has been a serious lack of investment in the overhead wire network, as a result of which the costs included in this evaluation reflect a significant upgrade of the overhead. Almost half of the extra cost of TBs is due to the maintenance and upgrading of the network. As the upgraded network is likely to have a longer life than the 10-year life assumed for the vehicles, it could be argued that the analysis is conservative in that respect.

> For the **base case** (diesel), the present value of net costs over the 10-year evaluation period was found to be **$8.9m**. This assumes that all 61 TBs are replaced by diesels in year 0 and also takes account of the cost of removing the overhead wire network.
>
> For the **TB option** the corresponding present value is **$18.3m**, assuming that the fleet is replaced over years 0 to 3. The additional subsidy required for TB relative to diesel is the scheme cost; this was found to have a PV of **$9.4m**.

Annual costs for both options are given in **Appendix A**.

If GW were to own the TB fleet then finance costs would be lower due to a lower return being required on the investment. To represent this, the financing part of the TB costs has been reduced by 10%; this reduces the PV of TB costs relative to diesel by $2m to $7.4m and increases the ER from 1.1 to 1.4.

4 ECONOMIC BENEFITS

4.1 Greenhouse Gases

Trolleybuses run on electric power which, in NZ, is generated from a number of sources. Some of these, such as Huntly Power Station, produce greenhouse gases (GHG) while others, such as hydro power, produce no GHG. There is no way of telling how the power used by TBs will be divided between the different sources. From previous work (the "Costs and Charges" study for MoT) Booz Allen understands that the GHG produced per TB km operated using power from Huntly is approximately the same as it would be for a diesel bus.

On the other hand, diesel buses emit GHG and the volume can be readily determined from the fuel consumption. This has then been valued at $40 per tonne as specified in PEM.

Following discussion with Transfund the evaluation has assumed that two-thirds of the GHG that would be produced by diesel buses would be saved (ie. two-thirds of TB power comes from a 'clean' source such as hydro). The benefits from this source are 5% of the total so the outcome would not change significantly if it were assumed that more of the TB power comes from a source such as Huntly. In practice it is understood that the general flow of electricity in NZ is from south to north so the figure of 67% is probably an underestimate.

4.2 Local Air Quality

Again, data obtained from an environmental expert during the "Costs and Charges" study has been used in evaluating the local air quality (LAQ) benefits.

The LAQ impacts of a TB can be taken as effectively zero and this is one of the most noticeable benefits of TB operation in Wellington, particularly along the "Golden Mile".

The cost per gm of particulate matter (PM) in Wellington has been calculated as $0.162. A typical diesel bus will produce 1 gm/km during "interrupted flow" (typical stop-start operation), rising to 1.24 gm/km for congested flow. Over the whole network and period of operation, the average of these has been taken, giving a total cost of $0.18 per km operated for diesel buses.

Considerable developments are taking place in addressing the volume of PM emitted by diesel engines and new vehicles (meeting the "Euro III or IV" standards) now have much lower emissions than the vehicles now on the road. The gradual improvement likely in the fleet has been reflected in the evaluation by reducing the LAQ benefits of TB relative to diesel by 5% annually.

The resulting LAQ benefits comprise around 27% of the total.

4.3 Noise

The noise benefits of TB relative to diesel are difficult to quantify and will vary considerably across the network. In parts of the CBD, where there is already a high level of traffic noise, the lower noise level of TBs will not have a large impact. However in other areas there will be a discernible difference between traffic noise with TB and with diesel.

Overall a value of 1¢/km operated has been taken as the benefit of TB operation. This is broadly consistent with other findings, including Costs and Charges and previous evaluations by Booz Allen. Despite the fact that this again is likely to be a "high profile" benefit of TBs in the public perception, the dollar benefit is less than 2% of the total.

4.4 Willingness to Pay

In 1998 shortly before the trolleybus contract last came up for renewal, WRC (as it then was) commissioned Pinnacle Research to examine the case for retaining the TBs. The research undertook surveys of residents in Wellington and was not limited to users of public transport.

The research concluded, *inter alia*, that residents were prepared to pay a small additional amount of between $8 pa and $23 per household per annum (assumed to be paid through the rates mechanism) to retain the TBs. Over the City of Wellington this translates to an amount in the range 0.5 to 1.5 $million per annum.

Comparing this to the present situation:

- Inflation has increased costs by around 15% since 1998
- Traffic noise and pollution have become worse
- The planned replacement of vehicles will overcome the accessibility issues.

The present evaluation has assumed a Willingness to Pay (WTP) of $1 million per annum. This is the middle of the 1998 range and does not take the three above factors into account, nor the fact that it related to the present vehicles, not the upgraded ones. It can therefore be said to be conservative.

However, even if it were practical, a repeat of the WTP exercise at the moment would be subject to serious bias in view of the run-down state of the fleet.

There may be a limited amount of overlap between WTP and the other sources of benefits. However the benefits due to savings in GHG (see 3.1) are a cost to society as a whole and represent the effects of global warming so are not double-counted. The LAQ costs are also largely a societal cost and while there may be an element of double-counting between this and WTP, it will be offset by the conservative assumptions in the $1m WTP valuation as discussed above. Putting this in context, inflation alone would increase the WTP benefits by $150,000pa, which is about one third of the LAQ benefits. WTP benefits also include factors such as the contribution the TBs make to the character of Wellington.

4.5 Generated Passengers

In the base case (diesel option), annual passenger growth of 2% has been assumed. This is below recent growth but is not unreasonable over the 10-year evaluation period.

The 1998 research by Pinnacle indicated that passenger numbers would be less if the TBs were taken out of service and this was supported by overseas experience where a similar move had been made. Given the clear attractiveness to residents of an updated TB fleet, an annual growth rate in passenger numbers of 4% has been assumed for the TB option, reflecting factors such as improved reliability. However, this "ramps up" over 4 years reflecting the time taken to replace the TB fleet.

Following discussion with Transfund, road user benefits have been excluded from the final monetised evaluation as it is understood these would be funded directly through PF. Nonetheless a potential move from car to PT is a clear benefit of retaining the TBs which achieves a number of objectives of the NZTS.

4.6 Reliability

The new TB vehicles are expected to significantly improve reliability and in particular the problem of vehicles becoming disconnected (“dewired”), thus delaying both the passengers in the bus and, in some cases, following traffic. It should be pointed out that many of the TB breakdowns occurring currently are not due to dewirements or other TB-specific factors; they are due to poor reliability as a result of a combination of the age of the vehicles and the fact that they are very intensively used. The average age of the diesel bus fleet is 8.5 years, compared to over 20 for the TBs; at this age a diesel bus would either be ‘retired’ or serving on school routes. In terms of distance travelled, the TBs have each covered well over a million km, again considerably beyond the point when buses are usually withdrawn.

When comparing the reliability of new diesel buses to old ones, Stagecoach report that there is a considerable improvement, partially due to age and partially due to improvements in design and components. They expect the same improvement to be achieved by the new trolleybuses.

Appendix B presents a communication from Stagecoach relating to the reliability and other improvements expected to be achieved by the refurbished vehicles. The key points are:

- Minimising dewirements was a significant component of the new TB design
- Fibreglass flexible poles are being introduced which, based on on-road tests, are estimated to half the number of dewirements
- The pole-head design has been improved which again will reduce dewirements, especially on bends
- The retrieval mechanism has been improved so that, should a dewirement occur, recovery is much faster than at present and the danger of wire damage is reduced
- A number of other systems, not specifically related to the wires, have been redesigned with a view to improved reliability and ease of maintenance.

It follows that there will be considerable benefits to both TB passengers and general traffic in improved journey time reliability. While PEM indicates that improvements in journey time reliability can be evaluated in some cases, this has not been attempted here. This is therefore another source of non-monetised benefits.

4.7 Overall

The above categories of benefit are believed to cover the majority of benefits resulting from the TB replacement. Intangible factors such as quality of ride and reliability will have been largely addressed either through the **Willingness to Pay** or **Generated Passengers**. Safety impacts are likely to be largely neutral between the two technologies, particularly given the low accident rate of buses compared to other vehicle types and recent steps taken by Stagecoach to improve trolleybus driver safety, as discussed in Appendix B.

The total tangible economic benefits have a present value of $10.2m over the 10-year life of the scheme. This does not include a number of significant benefits:

- Sustainability and the use of renewable fuel
- Generated passengers who transfer from car, thereby reducing congestion
- Improvements in reliability.

Benefits relating to the NZTS objectives are given in Chapter 4.

5 NON-ECONOMIC BENEFITS

Some information on this has already been supplied to Transfund, via form AF1. However the "highlights" are summarised in this chapter.

- Economic Development
  - an up-to-date TB fleet is likely to attract more passengers from car than the diesel alternative
  - new TBs will improve the reliability of Public Transport and also reduce the traffic impact of TB breakdown.
- Safety and Personal Security
  - reduced accidents resulting from transfer from private car.
- Access and Mobility
  - increases the access of the otherwise transport disadvantaged
  - new TBs meet modern standards of vehicle accessibility.
- Public Health
  - additional Public Transport use leads to more walking for access and egress
- Sustainability
  - significant impact on air quality, particularly in Wellington CBD; zero emissions at point of delivery.
  - significant reduction in GHG emissions
  - most or all the required energy source is renewable.

Notice that the diesel alternative fails to meet a number of these objectives, particularly in terms of sustainability and attracting passengers from car.

The Wellington RLTS places great emphasis on maintaining acceptable and safe levels of air quality in the CBD. For example, the LTCCP targets for particulate matter (PM10) and carbon monoxide (CO) are set at two-thirds of the national environmental standard. Currently the recorded levels are below the target but this will change as traffic levels increase. Reverting to diesel bus operation in the CBD will exacerbate this, particularly as it cannot be guaranteed that new vehicles will be replacing the TBs.

6 ALTERNATIVE TECHNOLOGIES

The use of Hybrid Electric Vehicles (HEV) has been proposed as an alternative approach which will reduce noise and emissions in parts of the road network while removing the need for the overhead wire network, which forms a substantial part of the additional cost of TBs.

HEVs are powered by a combination of electric traction and a diesel-powered engine or turbine. A number of different technologies are available. This type of vehicle is currently in use in Christchurch on the free city centre 'Shuttle" and on a similar service in Auckland.

The technology for HEVs is at a relatively early stage of development and does not yet appear to be at the point where it could be used for a significant part of the Wellington urban bus network without significant risks. These include reliability and performance, particularly in hilly terrain, and in maintenance requirements, given the complex technology used.

Costs of HEVs have been difficult to obtain but in general, compared to conventional diesel vehicles, it has been established that:

- HEV capital costs are 1.4 to 3 times greater
- Fuel costs may be lower
- Maintenance costs are higher but may fall as the technology develops and staff gain familiarity.

Using Stagecoach's diesel costings as a basis, approximate HEV costs were derived using the following assumptions:

- Capital costs are 75% higher.
- Fuel costs are 20% lower
- Maintenance costs are 20% higher

On this basis the annual subsidy required for HEV operation was found to be almost 50% higher than the equivalent figure for TB; the 10-year present value is $26.5m for HEV compared to $18.3m for TB. More details are given in Appendix A. In addition, HEV benefits will not be as great as for TBs because there are some emissions at the point of delivery.

The existing use of HEVs on two city centre services in NZ is very different in nature from having an large network operating throughout Wellington. For example, in Christchurch and Auckland there is no suburban operation, route lengths are much shorter and the nature of the terrain is very different; it should also be noted that the services are free. The existing HEV services in NZ are operated by much smaller vehicles and it is also understood that they are not without their operational problems. However, the argument is not that HEVs will not work in Wellington but that there are much higher risks associated with their use. The fact that they are operating elsewhere in NZ does little to allay these concerns, given the considerable differences. A web search on the subject indicates that worldwide experience has been, at best, mixed.

It might be argued that, with HEVs, tendering to operate the service would not be restricted to Stagecoach. However given the unproven nature of the technology it is unlikely that many operators would be interested in tendering for the operation. This argument is therefore unlikely to be borne out in practice.

Overall, both cost and risk factors mitigate against HEVs as a viable alternative for the present Wellington TB operation.

7 CONCLUSIONS

An evaluation using the current Transfund framework has been undertaken of the proposed replacement of the Wellington trolleybus fleet. Given the condition and design of the existing vehicles, they are in need of replacement and continued operation is not a viable alternative. In the light of this, the only alternative, which has been taken as the base case, is to replace the TBs with new diesel vehicles.

If the Stagecoach TB contract is renewed it would be for 10 years and this has been taken as the life of the evaluation. However over one-third of the additional cost of the TBs relates to the overhead wire network which has a much longer life and should therefore be discounted over a longer period. While this has not been done, it does mean that the costs given are overstated and the ER understated.

The present value of the additional costs of retaining TBs in Wellington has been calculated as $9.4m over 10 years, taking into account likely passenger increases.

The economic benefits of the TB option can be categorised as:

- Greenhouse gases (found to be 5% of the total)
- Local Air Quality (27%)
- Noise (2%)
- Willingness to Pay by Wellington rate payers (66%).

In total these amount to $10.2m (PV) over 10 years, giving an **ER of 1.1**. While there may be a small element of double-counting in the WTP benefits, this will be offset by the conservative manner in which they have been evaluated.

In terms of non-economic impacts, the TBs have been evaluated against the NZTS objectives and score well overall, but particularly so against environmental and sustainability criteria. They also score better than the diesel alternative in these areas. Factors such as the use of renewable energy sources, expected transfer from car and improved reliability have **not** been taken into account in the ER.

Hybrid vehicles have been examined but do not presently look sound in terms of either risks or costs. Reducing the size of the trolleybus fleet is not a practical option.

APPENDIX A: COSTS AND BENEFITS

year	Net Cost of Diesel	Net Cost of TB	Extra Cost, TB relative to diesel	Benefits of TB relative to diesel	Net Cost of Hybrid
0	$2,727,861	$2,350,985	-$376,875	$1,608,182	$5,343,370
1	$1,807,861	$2,797,075	$989,215	$1,582,673	$4,423,370
2	$1,587,861	$3,261,901	$1,674,040	$1,557,164	$4,203,370
3	$1,367,861	$3,805,414	$2,437,554	$1,531,655	$3,983,370
4	$1,147,861	$3,365,414	$2,217,554	$1,506,146	$3,763,370
5	$927,861	$2,925,414	$1,997,554	$1,480,637	$3,543,370
6	$707,861	$2,485,414	$1,777,554	$1,455,128	$3,323,370
7	$487,861	$2,045,414	$1,557,554	$1,429,619	$3,103,370
8	$267,861	$1,605,414	$1,337,554	$1,404,109	$2,883,370
9	$47,861	$1,165,414	$1,117,554	$1,378,600	$2,663,370
PV	$8,866,653	$18,259,466	$9,392,812	$10,227,412	$26,544,942
Ben-Costs				$834,599	

APPENDIX B: INFORMATION FROM STAGECOACH ON TROLLEYBUS IMPROVEMENTS

8 February 2005

Booz Allen Hamilton (NZ) Ltd

PO Box 10 926

WELLINGTON

Attention: John Bolland

Dear John,

RE: NEW TROLLEY BUS IMPROVEMENTS

I have provided further information and explanations of the key differences between the existing trolley buses and the newly designed buses from the view of what the effect the changes will have on reliability. I have also included some general comment on other changes not related to the bus design that we feel have an impact on the overall reliability of the network

It is important not to overlook the fact that the majority of the existing trolley buses in our fleet are over 20 years old. Each of these buses typically has travelled well in excess of 1,000,000 kilometres. The trolley buses operate on our busiest routes and are normally in service from 05:45 until midnight each day Monday to Friday. During the year 1 January 2004 to 31 December 2004 the trolley fleet carried approximately 4,500,000 passengers.

These are the oldest buses in our fleet and would have been removed from our fleet had they been diesel buses. The average age of our diesel bus fleet in Wellington is 8.5 years.

The perception of "unreliability" surrounding the trolley buses is largely due to their age and the amount of work that they are doing. They are highly visible and as can be seen by the above loading and kilometre travelled figures they are performing a substantial amount of the Wellington commuter transportation work.

The "in service breakdowns" that these buses experience from time to time is often for reasons that are not unique to trolley buses. For example they suffer failures to door mechanisms, windscreen wipers, power steering units, air compressors, heaters, lighting electrical systems and indeed are involved in accidents and have punctured tyres in exactly the same manner that diesel buses of a similar age do.

Many of the delays and disruptions to our services are caused by events outside of our control, for example when streets have been closed or blocked by accidents, emergencies, street parades and the likes. The disruption this causes is not unique to trolley buses as they equally affect our diesel fleet.

When comparing the reliability of old diesel buses to the new diesel buses we see that there is a considerable improvement, partially due to age and partially due to improvements in design and components and we expect the same improvement of the new trolley buses.

There is of course the additional complication to reliability and that is the overhead wires and the potential for the trolley poles to detach from the wires. Minimizing dewirements was a significant component of the new trolley design. It is our view that the radical design changes that the new buses will have will drastically reduce the incidents of dewirement.

Improvements that have been developed for the new trolley buses:

- **Flexible Fibreglass Poles**

  Flexible fibreglass poles have been extensively tested on two standard buses and were found to dewire notably less than the existing alloy poles.

  We have been able to estimate from our on road testing that the provision of new poles alone is likely to reduce the incidence of dewirements by around an estimated 50% over the current rate. We have conducted a survey of dewirements using the existing alloy poles across a section of drivers. It was found that on average the poles dewire every 440 Km's. This number should therefore increase to approximately 1 dewirement for every 880 Km's by using the new poles. Based on the above figures this translates to approximately 4,500 dewirements per year and we expect this to reduce to approximately 2,200 per year.

  It should be noted that this calculation does not take into account all the other design improvements being made to the new trolley so the actual improvement to the dewirement rate is expected to be much better.

There is an additional benefit in using Fibreglass Poles and that is they are externally non-conductive which removes the risk of anyone coming into contact with the outside of the pole receiving an electric shock.

The fibre glass poles are lighter, less likely to break and are not as susceptible to damage as the alloy poles which further improves reliability.

- **New Pole Head**

A new pole head has been designed that presents the Carbon Slipper to the wire at the correct angle, so that on bends, it has fewer tendencies to dewire. The Pole Head also has less gap between itself and the hemispherical Swivel, so that in a dewirement, there is less chance of it snagging on a Span Wire, which can be a cause of broken wires and live wires on the road.

New Pole head fitted to fibre glass pole

Old Pole Head

- **Pneumatically Powered Retrievers**

Pneumatically Powered Retrievers are being fitted. These eliminate the need for the driver to re-load the coil spring meaning less time on the road. The new Retriever does not rely on the Rope to pull the Pole down; therefore in the event of a broken Rope, it will still work. The retriever can be operated by the driver from his seat in circumstances that the poles need to be lowered. This reduces his on-road exposure from two events, one to lower the pole and one to replace it, down to just replacing the poles onto the wire. It also significantly speeds up the recovery time from a dewirement should one occur.

The pneumatic retriever “controls” the poles from the moment of a dewirement and lowers and centres them. This action prevents the pole extending into the overhead wires which can happen with the existing mechanical spring retriever resulting in damage to the overhead wires, span wires or the poles. It is important to note that we anticipate a substantial reduction in overhead damage and therefore a considerable improvement to reliability with fewer stoppages as a result of this measure.

The new Retriever System fitted to the test trolley

The existing retriever

- **Rope Guides**

  The Rope Guides on the new trolley have been redesigned to reduce the likelihood of passing trucks catching the ropes and breaking Ropes or Poles.

- **Pole Lights**

  There will be pole lights installed that are constantly trained on the Pole Head, by being mounted on the Pole itself. This will make it easier for the driver to fit the Head to the Wire, again speeding up the return to normal service by the trolley.

- **Auxiliary Systems**

  We have designed a new auxiliary system for the new trolley that is far less likely to fail hence bus reliability will be improved. The auxiliary motor fitted to the old trolleys drives such items as the compressor, power steering and battery charger. This has been eliminated in the new bus and replaced with an electrical invertor which draws DC current from the overhead and converts it to 24 volts and 230 volts AC to power separate electric motors to operate the above items.

New Inverter System

There are several benefits in doing this as we have now been able to run these items directly thereby removing the need for the belt driven system that is often the cause of trolley failures. The further benefit is that the new trolleys will be even quieter than the existing trolleys.

Old Auxiliary Set

- **Braking System**

The braking system in the new trolley has been designed to eliminate the Telma brake. The Telma brake is an electric brake incorporating a flywheel that is attached to the driveshaft. This technology is outdated, heavy and becoming unreliable.

The new bus employs rheostatic braking and requires the traction motor to be rewound. The benefit of doing this is that under braking the motor generates electricity which is run through a resistor mounted on the roof. This in effect provides engine braking, much the same as you would find in a petrol or diesel powered vehicle.

A further development is that the driver will be able to operate the braking resistor via a switch on their console to draw electricity when required to operate a "switch" in the overhead to enable them to change lines.

At the moment to change overhead lines to move onto another pair of wires the driver needs to accelerate when close to the switch. This draws a current that then triggers the switching device on the overhead allowing the trolley to change lines. To pass through the switch the driver needs to go reasonably slowly so the effect is the driver accelerates to trip the switch then brakes quite firmly to pass through it without dewiring. This manoeuvre often causes dewirements, particularly among the less experienced drivers, and sometimes causes damage to the overhead.

The acceleration followed by quick braking reduces passenger comfort.

With the introduction of the ability to control this from the console and without the need for the acceleration and deceleration we will see the removal of one of the main causes for dewirement. We will also see the provision of a smoother, more comfortable ride for passengers.

- **Trolley Chassis**

The new trolley is a modern SLF Bus with wheelchair access ramp, the body is aluminium body, which provides less weight and will likely reduce the incidence of dewirement.

New Prototype Trolley

- **Bus Lanes**

The Wellington City Council has introduced a significant number of bus-only lanes which give our buses, particularly through the CBD exclusive access. This removes the conflict with other traffic thereby making it safer for our staff. In August 2004 a further lane was introduced in Glenmore Street and two existing ones, Adelaide Road and Kaiwharawhara Road were lengthened. The City Council has further bus lane initiatives planned and we expect these to be phased in over the next year or so.

Karori Bus lane

- **Engineering Maintenance**

The new trolley has been designed with ease of servicing in mind. In the unlikely event of a breakdown many of the servicing tasks can be carried out on the side of the road, rather than having to tow the bus back to the depot as is often the case now.

This has been achieved by ensuring much of the access to the electronics is gained from within the bus. Many of the servicing functions can be carried out by mobile engineering staff without the need to return the bus to the workshop. This feature will ensure that the trolley is quickly returned to service. The electronics are given far better protection from the elements in the new bus, again this will enhance reliability.

With the expected dramatic improvement in reliability there will be much less disruption to other road users due to the reduction in use of our tow truck.

We have also invested in a comprehensive computer package, which tracks our fleet servicing and management. From this we can derive information that will assist in the preventative maintenance as well as assisting engineering staff to track common or persistent vehicle faults.

Conclusion

It is our view that the new trolley bus will provide far greater reliability and have much fewer dewirements as a result of the design changes that have been undertaken.

Many inner city pedestrians, shopkeepers and residents resent the noise and fumes of diesel buses. Even though new generation buses introduced since the late 1990's are lowering emissions and noise levels, they are still not as environmentally benign as trolleys, particularly in the proximity of pedestrian crowds, say on Willis Street/Lambton Quay.

The futuristic look of the new trolleys will greatly enhance the image of public transport in Wellington at the same time as preserving the environmental benefits the trolleys deliver whilst removing the drawbacks that we experience with the aging existing fleet.

Accordingly, there are very strong environmental grounds, including issues of health/ noise/fumes/hydrocarbon deposits that make the current compromise of a mixed fleet, a very strong public expectation. We feel our trolley buses are playing an integral part within the Wellington CBD in reducing Particulate Matter Emissions. This is particularly important at a time that the Government is striving to reduce such emissions.

Yours sincerely

STAGECOACH WELLINGTON

Nigel Piper

Commercial Manager