Feature

The Hong Kong Airport Railway

Alastair J. Budge-Reid

Background—The Beginning

This article describes the principal challenges and responses developed by the Mass Transit Railway Corporation (MTRC) in moving from the initial concept defined by the Hong Kong Government (HKG) to a firm and committed project for the Hong Kong Airport Railway.

In November 1989, the HKG announced its decision to build a new Hong Kong International Airport at Chek Lap Kok, together with nine related infrastructure projects that became known as the Airport Core Programme (ACP) projects. These all required massive investment by the HKG and included a high-speed rail system to serve the new airport. Following the HKG's invitations for expressions of interest, the MTRC signed a Memorandum of Understanding with the HKG in which it agreed to participate in feasibility studies for the high-speed rail system and, subject to satisfactory findings, to enter into an agreement to design, build, finance and operate the Airport Railway (AEL).

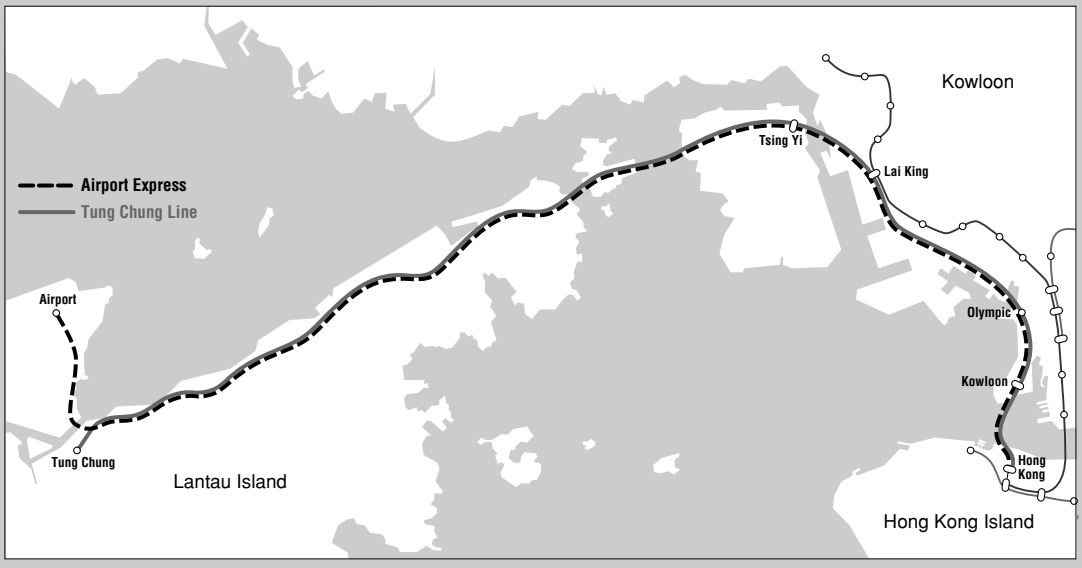
Tsing Ma Bridge in Lantau Link *(MTRC)*

Financing and Programme

Financing

The MTRC was established by law as an autonomous body wholly owned by the HKG for the purpose of constructing and operating, on prudent commercial principles, a mass transit railway system having regard to the reasonable requirements of the public transport system of Hong Kong. As sole shareholder in the MTRC, the HKG invested capital in the MTRC network, reflecting its commitment to

Figure 1 Route of Hong Kong Airport Railway and Tung Chung Line



building an efficient public transport system. As the operations have become profitable, the MTRC paid dividends on the investment by the HKG. The MTRC railway network is running at a profit and receives no subsidy.

It was therefore proposed that there would be 'four pillars' to underpin the financing of the AEL project: injection of initial equity by the shareholder (to be kept as low as possible); deferral of dividend payments on previous investments to the shareholder; profits from railway-related property developments, and borrowing on the financial markets. Subsequently, the equity injection by the HKG was increased, thus reducing the need for borrowing. To some degree, this offset the financial consequences of delays to the start of the project while talks between the UK and China proceeded.

Programme

The HKG originally decided that all the ACP projects should be completed by mid-1997. However, questions were raised in some quarters about whether the AEL was needed on 'day one' of the airport operation, because, in the early years, there would be no congestion on the roads to the airport. As the feasibility study progressed, it became clear that the initial ridership would not meet original expectations, but given air passenger forecasts and road bridge toll assumptions, it was still possible to demonstrate that even with no protection from competition, the project remained viable. Also, providing equivalent transport capacity by other means, such as buses and taxis, would create many other problems due to the numbers of vehicles required. In addition, there would soon be a need to relieve the crowded Nathan Road section of the MTRC's Tsuen Wan Line (TWL) which could be provided by the AEL. Therefore, it was confirmed that the AEL should be available from 'day one.' The actual Airport programme was subsequently delayed by external factors and 'day one' eventually moved to 1998. The AEL Project construction programme remained constant at 43 months throughout all these changes, but the initial uncertainties and changes to the starting date, which was not approved until November 1994, interfered with the overall programme and created significant interface problems between contracts, both in design and construction.

Team Building—Benefits of Experience and Managing Change

When it was established, the MTRC was necessarily a 'hands-on' construction-orientated organization that built three lines in quick succession between 1976 and 1986. However, following the completion of the third Island Line in 1986, the Project Division, which had been responsible for delivery of new lines, was disbanded. The MTRC then concentrated on responding to increased ridership and passenger demand by improving levels of service and reliability on existing lines. The Eastern Harbour Crossing link completed in 1989, had been designed and constructed by others using essentially the same design standards as used for the Island Line. It was a very successful project in terms of benefits to the MTR network and became an extension to the existing system.

However, due to the size, complexity and uncertainties of the AEL project, the original hands-on approach to project management was adopted again. The problem at the outset was to rebuild a project team and to re-create a project-orientated environment. Fortunately, there were still some staff remaining from the earlier projects. With time, it was possible to recruit back to MTRC a significant number of experienced engineers and architects who had previously been in the Project Division. This team formed a nucleus of expertise to address the questions of project definition and to revise the original design standards and specifications used for the first three lines. These required updating to benefit from the experience of 10 years of operations, developments in technology in the intervening period, and new standards of quality and system assurance, in the railway industry. They also required updating to take into account the significant evolution in the regulatory and statutory approval process and the expectations of increasingly more demanding and discerning passengers.

To manage these changes and to be able to respond to questions arising from the feasibility studies, a joint Design Steering Group was set up with members from the operators and maintainers of the existing system together with members from the MRTC marketing and planning divisions. The design standards and specifications at the start of feasibility studies, which had been used to design and construct the existing lines, were reviewed by this Steering Group to incorporate new knowledge obtained from operating the existing system, and to address the new requirements of a fundamentally different railway system serving an entirely new market.

Defining Project—Emphasis on Customer Requirements

A problem that appeared in several different guises during the AEL planning and feasibility studies was the absence of any suitable example of a similar railway to use as a benchmark. The challenge, therefore, was to determine what an air-rail link is exactly. Project definition encompasses all levels of detail from the high level strategic statements of purpose, through the service requirements, the functional requirements and down to the design standards and specifications needed to deliver the product. Fixing these issues proved to be one of the greatest challenges.

The first objective, set by the HKG, was

AEL Train *(MTRC)*

that more than 50% of all airport trips should be by rail. This would ensure that the maximum amount of the relatively restricted highway capacity over the Lantau Link would be available for freight and commerce. The second objective, an MTRC objective, was that there should be an acceptable commercial return on the investment, commensurate with its objective of building new lines only when there is a proven transport need and where it is technically and commercially prudent to do so.

The declared strategic intent of the HKG and its policy support aligned the many disparate parties, in particular those parties developing the master plan for the new airport and the related infrastructure projects, who had their own priorities. For its part, the MTRC applied appropriate checks and balances to control expenditure and achieve the transport objectives. At every stage and as the technical elements were defined, customer service and passenger demand tests were applied and, where practicable, used to determine choices for the project design.

Two quite separate services were required to run on the Airport Railway. First, a dedicated high-speed rail service was required to provide quick, convenient and reliable access to the new airport, linking it to the downtown business districts of Kowloon and Central Hong Kong. Second, an urban-type MTR service, similar to the existing services, was required to provide domestic mass transit services between Tung Chung, a new town being built to service the new airport and other new development areas on the north shore of Lantau Island. In addition, passenger predictions for the existing MTR system also indicated a pressing need to relieve congestion in the Nathan Road section of the existing TWL. This could be achieved by the proposed new line from Tung Chung if a fast and convenient interchange could be created between the old and new lines. The new railway was thus defined by two services: the dedicated airport link or *Airport Express* (AEL), and the domestic or MTR service, now called the Tung Chung Line (TCL), running where practicable on the same tracks.

Cost Estimates —Making It Happen

The preparation of estimates presented some challenges. There were few cost-estimating rates for works of similar or comparable magnitude and complexity and no reference projects from which to benchmark. The only cost estimate database available for much of the heavy civil engineering work was derived from the Island Line completed in 1986. Similarly, although some data was available from the Eastern Harbour Crossing completed in 1989, very little cost information was available for the most modern railway electrical and mechanical systems, the nature of which had evolved significantly over the intervening period.

Consequently, designs during the feasibility study stages were very preliminary for a project of this size, given that each of the airport railway stations had a footprint of over 4 hectares in plan with multiple levels above and below ground. Each station presented design challenges similar in magnitude and complexity to those for the airport terminal building itself. Even so, an estimate was prepared for the railway that was incorporated without change into the AEL Agreement many months later and that remained as the project budget. The railway works, including those incorporated into government projects and inclusive of design, supervision and all corporate on-costs amounted to HK$35 billion (US$4.5 billion) at out-turn.

Apportionment of costs

The stations formed the substructure of the aboveground commercial developments, but there were no parallel designs for the railway with and without the commercial development, which would have allowed identification of the marginal additional cost to the railway of the property development requirements. Therefore, it was necessary to develop apportionment rules

to determine the contribution of property development to the overall works costs. Provisions to recover these costs were incorporated into the property agreements. The total cost of the whole project inclusive of development foundations and infrastructure associated with property development is approximately HK$48 billion (US$6.1 billion) at out-turn.

Property Development —A Case of Mutual Benefit

Profit from property development, an essential 'pillar' of the financial support for the AEL, had been a feature of all previous MTR lines. Rather than buying land at public auction, which is the usual means of land disposal by the HKG, the MRTC negotiated a private treaty grant with the HKG to buy at commercial valuation prices for developing sites above stations, depots, associated transport interchanges or for other reasons intimately linked to the railway construction or operation. The MTRC then develops the sites as a joint venture with a private developer and enjoys a share of the development profit, which is used to finance the railway.

In addition to the obvious financial rewards, there are several benefits from this approach. Significant population centres are created immediately above or near stations and this encourages ridership on the railway, benefiting the operator and the whole community. Living near an MTR station is seen by people as a significant advantage and property values rise accordingly. In addition, by integrating railway and property development under one umbrella, construction of apartments is accelerated, helping to solve Hong Kong's chronic long-term housing shortage. The approach also has urban planning benefits by integrating transport facilities, civic amenities, housing and commercial developments more effectively. Each of the AEL development sites was very large indeed, and each was considered to be a Comprehensive Development Area (CDA) in its own right. Although the principle of property development was acknowledged in feasibility and other studies and some initial development schemes were prepared to ensure that the railway planning would be compatible with future development, no firm large-scale schemes could be decided in the AEL early planning stages. Like all design processes, development of property master plans is iterative, and although the first schemes, developed within the feasibility and other studies were helpful in defining what should be provided above the stations, they were by no means final.

To address this problem, a strategy was devised whereby the Brief to the design consultants for the detailed design of the railway included as a first stage, preparation of the initial stages of the development Master Plan. This Plan was then developed in parallel with the railway design by independent teams with appropriate communication. Convergence was achieved once more at the Town Planning Board statutory approval stage that was required prior to the start of construction. While this strategy was essential to enable the air rights development to proceed, it rendered the railway designs vulnerable to change to suit urban development needs and in fact several radical changes were made to the station designs from those developed at feasibility stage and used for project estimating purposes. In fact, the problems of project definition for the CDA Sites are as challenging in their own way as those facing the railway and ultimately may only be finalized by the developer who takes the commercial risks. The total number of apartments being built in AEL-related property developments exceeds 24,300 with a total gross floor area (GFA) of some 1.932 million m^2. In addition some 644,000 m^2 of commercial space and 316,000 m^2 of retail space, as well as 9 hotels with a total GFA of over 375,000 m^2, are being planned and built.

Proposed property development at Kowloon Station site *(MTRC)*

The Route Alignment —Finding The Way

Unlike all previous MTR lines, which are located along existing transport corridors through the most densely populated districts of Hong Kong, the route to the airport was largely unpopulated and ran for most of its length on newly reclaimed land that did not even exist at the time of the feasibility studies.

The new transport corridor was primarily for the highway network, so the railway had to fit within the highway corridor wherever possible. The railway and infrastructures had to be included in highway works contracts to meet the overall ACP programme prior to any firm commitment to the AEL project or any agreement between the HKG and the MTRC. This included provision for the railway over the Lantau Fixed Crossing, now known as the Lantau Link. An at-grade or overhead alignment was used wherever possible, with underground sections being kept as shallow as practicable, consistent with minimizing the cost and maintaining ease of passenger access from the surface.

Due to bridge load restrictions, tunnels were considered for the Lantau Link but they were not cost effective. The commitment by the HKG to incorporate the railway works as essential infrastructure into the Lantau Link, even before the AEL agreement was concluded, was a decisive factor in the MTRC's 'day one' operating strategy.

AEL's Hong Kong Station was located within the Phase-1 works of the Central District reclamation area. Due to space constraints, only one AEL platform could be provided. Phase-2 and completion of the Station depends upon further reclamation following relocation of the Star Ferry piers to allow construction of an overrun tunnel and full turn-back facility.

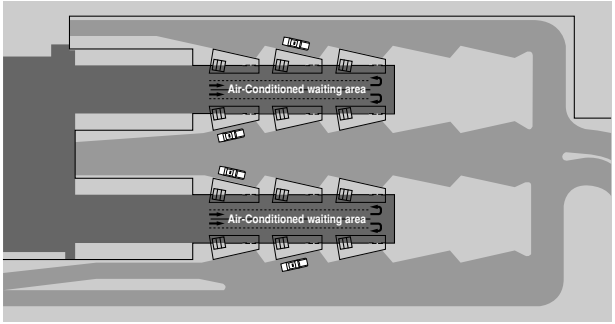
The design of the interchange between the TCL and TWL had to provide the maximum convenience and minimum transfer time for passengers, because this would be the only way to attract passengers from the TWL to the TCL, thereby relieving congestion on the Nathan Road section of the TWL. By taking advantage of the configuration of the tunnels at Lai King Hill, it was possible to switch the existing line into a new station alongside Lai King Station, thus facilitating cross-platform interchange between TCL and TWL in the peak flow direction.

Transport Interchanges —A New Experience

Although most riders on the existing MTR network live or work within walking distance of a station, this is certainly not the case for the AEL. Access to and from AEL stations was predicted to be divided by mode as follows: taxis 43%; private cars 11%; hotel vehicles and coaches 10%; franchised buses & other public transport including the MTR 17%; luxury feeder buses 13%; walking 6%. Since most passengers at the AEL stations will arrive and depart by taxi or other road transport, the layout of the stations had to provide better access for these vehicles than at previous MTR stations.

To achieve maximum convenience and access, the ideal arrangement is for vehicles to set down and pick up at the same level as the platforms. However, the predicted design flows made it impossible to provide sufficient length of kerb within the stations to permit this. Consequently, a two-level design was adopted with ample provision for change of level by passengers with or without luggage via lifts and escalators. Experience from Hong Kong's Kai Tak Airport and elsewhere suggested that a more regulated and controlled pick-up arrangement might be possible if flexibility for taxi drivers could be maintained. The design allows passengers to queue for taxis within the air- conditioned station environment and only moving to the kerbside when a taxi is available. To achieve the required flow, saw-tooth kerbs were adopted to allow one taxi to pass while another is loading. This arrangement together with inter-digitated passenger piers and taxi lanes permits simultaneous loading of up to 20 taxis

Figure 2 Design of Air-Conditioned Taxi Piers



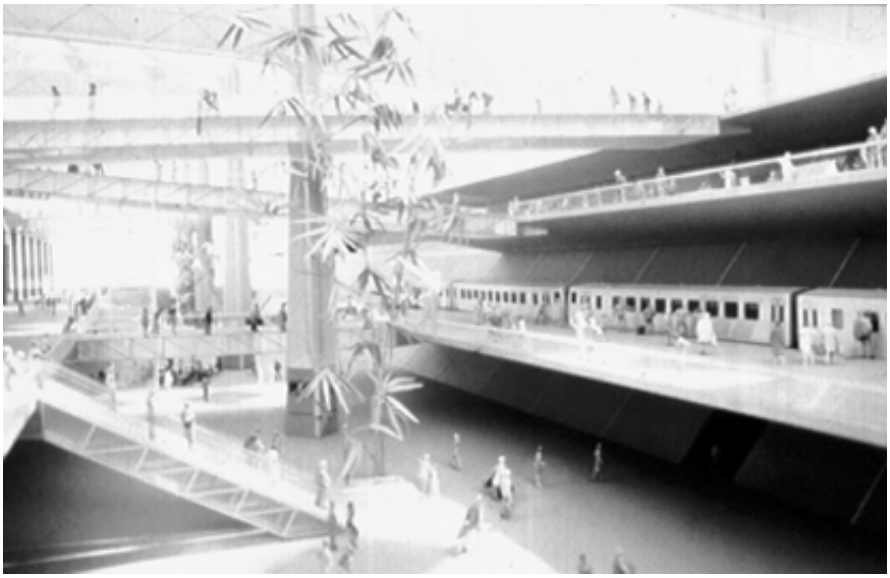
Design concept of taxi pickup area *(MTRC)*

within the smallest possible area. Trials were carried out in liaison with the Taxi Drivers Association to ensure their support. Figure 2 show the taxi layout at Kowloon Station.

Station Design —New Design Concept

The key attraction of any air rail link is speed and reliability, which reduce the stress of international travel. The AEL was designed to create the feeling that arriving at an AEL station is tantamount to arriving at Hong Kong International Airport at Chek Lap Kok. Design features and concepts in keeping with an airport and air travel were introduced to create an airport environment at the stations. Whilst retaining the required characteristics of durability and low maintenance costs, a higher specification for finishes was adopted for the AEL stations and natural daylight was admitted whenever possible. Other features such as flight information displays, improved access for those with impaired mobility and customer services appropriate to an air traveller such as food outlets and additional commercial facilities were planned. Another major feature and cost consideration for the AEL stations was provision of substantial transport interchange facilities, bus terminals and car parks facilitating connection to the AEL. These are described in more detail below. However, the TCL stations had to conform more closely to the existing system because they are part of the MTR network. Nevertheless, to meet the public's increased expectations for a system more modern than the Island Line completed in 1986, the opportunity was taken to upgrade finishes and to improve the railway environment with respect to noise and air-conditioning.

In adopting a shallow alignment for the AEL to facilitate access, a significant part of the station buildings were above ground, creating the need to consider the exterior finishes and to take into account the requirements of property developments integrated with the stations.



Airport Station concept *(MTRC)*

The Airport Terminal —A Unique Opportunity

The unique opportunity presented by the simultaneous construction of an entirely new airport and airport railway on a green-field site, enabled the original Master Plan to place the arrivals and departures railway platforms at the same levels in the terminal building under the same roof.

However, this arrangement could not be sustained during the airport design development stages due to the barrier that the platforms presented to access to other transport modes. Therefore, the platforms were relocated to the Ground Transportation Centre outside the terminal building. However, the key customer service requirement of easy access to and from the AEL was maintained by using link bridges and the relatively small increase in distance was ameliorated by provision of moving walkways.

The Rolling Stock —Transport Identity

The high-speed AEL has to compete effectively with road-based transport in terms of journey time and reliability, while maintaining efficiency and holding energy consumption to acceptable levels. Given the relatively short total journey of 34 km, the distance between the four stations (Hong Kong, Kowloon, Tsing Yi, Airport) and the constraints on acceleration and braking rates, a maximum operating speed of 135 km/h was selected. This is not high in modern railway terms but is significantly higher than the 80 km/h of the other MTR lines. Analysis of passenger demand and customer profiles showed that emphasis should be placed on a higher standard of comfort for airport passengers, ideally using a 'business class' model. All passengers should be seated on good-quality seats similar to aircraft seats with passenger information systems, including multi-channel seat back video displays. Air travel projections from the airline industry indicated that ten-car trains would eventually be required while passenger predictions for the TCL confirmed that

Improved facilities for disabled persons *(MTRC)*

eight-car high-capacity trains would be required eventually.

Since both the AEL and TCL trains were to run together over significant lengths of the same track, the performance of the two trains had to be identical, a fact that would bring benefits at the tender and construction stages. Initially, the AEL headway was planned at 8 minutes, falling to 4.5 minutes in the design year and providing a final capacity of 10,000 passengers per hour with some passengers standing. The TCL service would be provided by interleaving two TCL trains between each AEL train, with one TCL train turning back at Tsing Yi. In the design year, this pattern could provide 2.25-minute services between Hong Kong and Tsing Yi and 4.5-minute services to Tung Chung. This pattern gave the ultimate required design capacities of 66,700 and 33,300 passengers per hour on the TCL.

The basic rolling stock design assumed that the cars would be the same size as those of the existing fleet, allowing passage but not operation of the new cars through existing tunnels. Also the basic interior configuration of cars for the TCL was to be similar to the existing fleet, as was the door configuration. However, in most other respects, it was intended to take advantage of the most recent developments in rolling stock to achieve better performance and reliability with the new fleet. The AEL trains in particular would have to meet the increased expectations of air travellers.

The interior noise specification was set to a much quieter level than that on existing trains. This was both to improve intelligibility of train announcements and to create an AEL interior environment more consistent with the business class image. The external noise generation was set to the minimum practicable level to meet increasing pressure from the environmental lobby and increased public sensitivity to noise. Since new rolling stock would be used on entirely new track, a resilient track support system was adopted and the vehicle suspension and track support were designed as one dynamic system, thereby achieving better wear and noise performance than possible on previous lines.

Baggage Handling and In-Town Check-In

Air passenger surveys and consultations with the airline representatives made it possible to estimate the luggage likely to be carried by each passenger and thus to design the baggage space provisions on AEL trains. Luggage racks have been provided at each vestibule in sight of seated passengers. In addition small bags can be stored under seats, which are cantilevered for maintenance and security purposes.

The feasibility study showed that AEL ridership and revenues could be increased significantly by providing an In-Town Check-In (ITCI) service, so passengers could check-in their bags at a station and then travel unencumbered to the airport by the AEL. Studies confirmed that ITCI was feasible and could increase ridership. Unfortunately the requirement for Customs control at the airport, together with the size of any baggage reclamation facility, precluded the possibility of an In-Town Check-Out (ITCO) service.

To provide the ITCI service, the AEL train configuration was revised to include one baggage car at the end of each train, resulting in nine passenger cars and one baggage car. However, because no ITCO service could be provided on the return journey, no reduction in luggage space within the cars was possible.

Baggage security problems were resolved by introduction of a new bulk X-ray device, known as MAEDS (Mechanized Automatic Explosive Detection System) which was undergoing trials at a number of international airports. This system enables all baggage from all check-in desks to be screened in bulk in the baggage-handling hall rather than at the check-in. The great benefit is that only normal security and not 'air side' security is required within the MTR system. MAEDS has been adopted for some functions at the new airport and the ITCI has been planned accordingly.

Luggage trolleys are an essential feature of AEL stations. During early discussions with the Railway Inspectorate regulator for safety, it was decided that luggage trolleys could not be allowed on the trains. However, the stations have been planned to allow trolleys to be used to move luggage between platforms and carriages

Hong Kong In-Town Check-In Hall *(MTRC)*

with full provision of lifts for those needing to change level. The ticket barriers have been designed to allow passage of passengers with trolleys and recirculation of empty trolleys away from the public.

Conclusions—The Next Step

Building the AEL presented unique challenges, and this article has touched on some of the many issues including financing and operation addressed during the initial project planning, feasibility study and design stages. More detailed information on the construction aspects is described in the *Proceedings of the Institution of Civil Engineers*[1]. The most problematic issues have been associated with defining such an interdependent project, and of managing designs in the context of a rapidly changing political process.

Project definition was particularly difficult when the project played a central role in multiple interrelated development projects and transport networks. A major project of this kind is particularly vulnerable to design changes and their attendant cost and programme implications.

First, both the clients and project team alike must make their best efforts to understand the process to be adopted, and to set down procedures for managing and controlling this from the very outset.

Second, it is vital that there is a good understanding of the political processes and broader economic and social context in which the project is to be created. All levels of the organization must understand how these can influence even the best plans and must be able to meet the challenges and manage risks constructively. Also, consideration of how the cost and financial risks might be addressed in the public arena from the outset, to promote informed public opinion and policy decisions, is time well spent.

The AEL was completed on schedule and opened for public service on 6 July 1998. It currently operates on a 10- minute headway between 06:00 and 01:00. The TCL operates a 5- minute service at peak hours. The service frequency will be increased as passenger numbers build up. Despite very aggressive competition from buses and other road-based transport, the passenger response has been very favourable and is showing a steady increase in market share.

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Notes:

1 Crighton and Budge-Reid. *Proceedings of the Institution of Civil Engineers (UK) Civil Engineering Special Issue: Hong Kong International Airport, Part 2: transport links.* November 1998, ISSN0965 089

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