Journey and Arrival

The story of the Melbourne CityLink
Journey and Arrival

The story of the Melbourne CityLink
# Contents

## Part I  Social, Economic and Political Dimensions

1. Urban dilemma: the historical context  
2. The groundwork: hurdles and breakthroughs  
3. The contract: new boundaries for private sector risk  
4. The momentum builds  

## Part II  The Technological Dimension

5. Electronic tolling: the silent force behind CityLink  

## Part III  Engineering Dimensions

6. The Monash Freeway bridges: rejecting obvious solutions  
7. The Western Link: the spirit of an open road  
8. The tunnels: watershed test for Australian engineers  

## Part IV  The Future

9. The road ahead
Very few infrastructure projects have produced such a comprehensive impact as Melbourne’s CityLink. It has not only changed the landscape and lifestyle of the city; it has also set a new benchmark in the partnership between the public and private sectors in undertaking infrastructure projects. CityLink has created leading-edge technology in road tolling, being the first in the world to use full electronic tolling for a toll road with more than 10 entry and exit points. Importantly, CityLink has significantly reduced commercial transport costs in Victoria, resulting in a vast improvement in the State’s industrial competitiveness.

This book captures the learnings from CityLink that will enrich Australia’s knowledge base in the area of infrastructure development. It records the key engineering, technological and business achievements of the project, and puts these in the context of the evolution of road building in Melbourne. It preserves the collective memory of the key people involved in such a benchmark project.

As in any major endeavour, those involved move on, or change roles. It is thus left to records like this to answer questions of future generations as to how a landmark project was achieved.

As a record of events and achievements, the book does not recoil from discussing the problems that were encountered. Indeed, the learning has been made more valuable by examining how the engineering, technological and financial hurdles were all overcome.

This is the very first complete account of the project, and will be a reference point for future publications on CityLink.

The Victoria Division of the Institution of Engineers, Australia is to be commended for its foresight; for recognising the need to capture the experiences on CityLink and keep them for posterity. In this regard, I would like to recognise the role of Ken Mathers, who, during his term as Chairman of the Victoria Division, initiated the project and guided it through to its completion.

I would also like to pay tribute to all the men and women who have contributed to the development of CityLink. Most of them will remain faceless and nameless to the people enjoying the benefits of CityLink, but that doesn’t in any way diminish the critical role each has played in creating this landmark achievement.

Finally, I hope you get as much pleasure as I have from reading and learning about CityLink.

John Laurie
Chairman, Editorial Committee
Social, Economic and Political Dimensions
Chapter 1. Urban dilemma: the historical context

CityLink is the solution to a problem that began as soon as John Pascoe Fawkner, one of Melbourne’s founders, supposedly uttered the words: ‘This is the place for a village’. The year was 1835. The English-born trader had sailed from Launceston across Bass Strait, and laid claim to land close to Port Phillip Bay. The settlement attracted all manner of fortune seekers, and before long, all roads led to the village. Thus was the scene set for the modern problem of traffic jams.

Fawkner, and John Batman, who has legitimate claim as the other founder of Melbourne, were commercial adventurers from Tasmania attempting to ‘colonise continental Australia in the south.’¹ Both saw Port Phillip as a bridgehead for swift invasion of sheep and cattle. Both had visions that one day, their settlements would become a city inhabited by rich merchants. Batman, however, did not live to see his vision come true — he lived in Melbourne for only four years, dying in his settlement at the age of 38.

The location of Fawkner’s village was logical and obvious. It was at the head of the vast bay, on the north banks of the largest river emptying into it — in the vicinity of the present-day Rialto Building on Collins Street (see map next page). It was as far up the Yarra River as it was possible to navigate and turn a sailing ship. It also ensured safe harbour, ease of loading and most importantly, good access to fresh water.

By 1836, sailing ships began arriving, more and more of them laden with sheep, cattle and settlers. The vessels slowly worked their way up the river and moored to stumps close to the banks. The water was fairly deep and even without a wharf the unloading of a ship was not difficult.

The primitive village quickly grew into a thriving port. But it stayed entirely on the north bank, with houses huddled at the western end of the present city. The central business district (CBD) was close to the coast with a swampy, muddy river delta in between.

From punts to bridges: 1840s

As the village grew, the problem of human and livestock traffic began to rear its head. This was especially so when the south side of the river attracted some settlers, while people on the northern bank began taking their cattle across to graze on the southern fields. Punts were built to handle the traffic, but most people felt the crossing was ‘very unpleasant when the bullocks and passengers got mixed up.’² Thus began the building of Melbourne’s...
many bridges, linking parts of the town separated by the Yarra. The first one was erected in 1845 — at five metres wide, it was already considered inadequate before it was finished.

With the bridges also came the beginnings of a formal road network, and by the mid-1850s, Melbourne’s modern road network — the arterial roads and most of the street grids — was already in place.

The 1850s gold rush: roads under strain

The discovery of gold in the 1850s, which triggered a sudden increase in population and business activity, tested the capacity of this road network. Melbourne became not just a gateway for settlers, but the transport hub of the richest gold fields the world has ever seen, stretching across Victoria.

As the news of gold reached other countries, Melbourne was deluged with gold-seeking immigrants, and the rudimentary infrastructure creaked and groaned under the strain. By the end of 1854, more than 140,000 immigrants had arrived from the British Isles, more than 20,000 from China and other foreign ports, and nearly 110,000 from other Australian ports. While most settled in the gold fields, large numbers also settled in Melbourne, seeking their own fortune by providing goods and support services to the mining settlements. Melbourne’s population increased from 29,000 to 125,000 in a single decade.

Dr Max Lay, a pre-eminent road historian, says the location of the rapidly growing city was a barrier to the free flow of traffic around Port Phillip Bay, and between the city and the rich gold fields of Ballarat, Bendigo and Mount Alexander (now Castlemaine).

It is not difficult to imagine Melbourne’s arterial roads congested with traffic, not of cars but of people and livestock, of bullock drays laden with supplies to the mining settlements, and of fast horse cabs carrying impatient gold diggers on their way to the banks in the central business district. Indeed, successful diggers were particularly fond of getting around town by horse cabs and egging their charioteers to drive recklessly. People being trampled to death by horses was almost a daily occurrence during this period. This would have been one reason why some colonial administrators referred to Melbourne of the 1850s as the ‘the topsy-turvy city’.

The steam train relieved some of the chaos on the roads — but only just. Melbourne’s, and Australia’s, first steam train rolled out of Flinders Street station in 1854, bound for the other terminus at Sandridge, which is now Port...
Urban dilemma

Melbourne. It was a privately run line and was the beginning of the network of Melbourne’s suburban railways, all developed by private companies. However, none of the lines ever became profitable so the private railways languished for some time.

Industrialisation and the rise of the suburbs: 1860s-1870s

The gold rush spurred both the urbanisation and industrialisation of Melbourne. By the early 1860s, small factories began to spring up in the riverside suburbs of Collingwood and Richmond, producing the necessities of life — such as food, clothing, boots and shoes — for Melbourne’s own burgeoning population and those of the flourishing mining towns. Meanwhile, the vast wealth from the gold fields poured into the financial institutions of Melbourne, and numerous businesses set themselves up in the city to cater for the nouveau riche of the day.

The growth of Melbourne was puzzling to visitors, particularly those from Europe. The city straggled and spread over a much larger area than European cities which had much bigger populations. For some Melbourne residents, the sprawl of the city was something of a burden. A temporary resident of the time, Clara Aspinall, wrote in 1862, in her Three Years in Melbourne: “The distance from one suburb to another is great, consequently the expense of getting, in any sort of conveyance, from place to place, is very considerable.” Aspinall would have been referring to the ubiquitous horse-buses or omnibuses, and the steam trains that linked the city to its outer suburbs.

The next two decades saw the growth of even more factories and businesses around Melbourne. Most of the factories were set up to replace expensive imports from Europe, and were as diverse as biscuit machine manufacturers, paint manufacturers, cooking stove makers and chandelier makers. Melbourne was unlike most other cities that grew up around a single product, such as Pittsburgh’s steel or Manchester’s linen. This enabled it to quickly develop the broad industrial base of a fully fledged metropolis. During the same period, many of the large, mostly British-owned companies established their headquarters in Melbourne. New finance houses and exchanges also set up operations in the city, making Melbourne the new financial centre of the colonies.

The frantic pace in the city during the late 1870s set off a new phenomenon — suburbanism. Work-weary men
longed to renew their spirits and re-invigorate their bodies, and the allure of a home in the suburbs, away from the busy commercial world, was irresistible. A defining characteristic of this suburban exodus was the single-storey, single-family dwelling, built on a quarter-acre block that allowed the dwellers to engage in horticulture. The families were escaping from the fenced-in atmosphere of the terraces and attached houses in the city.

**Melbourne's first trams: 1880s**

The sprawling suburbs inevitably required a more efficient means of mass transport. While the horse-drawn omnibuses continued to serve commuters well, people were beginning to grumble about jolting and bouncing over rutted roads. They had heard of the smooth-running trams in Europe and the United States and they were ready for the ideas and plans of the cunning businessman Francis Boardman Clapp, an American resident of Melbourne. Clapp set the wheels in motion, and in 1885, Melbourne’s first cable tram line was officially opened. This rolled from Spencer Street, along Flinders Street and Bridge Road about 5 kilometres to Hawthorn Bridge. It formed part of the present route of the East Burwood and North Balwyn Lines. Other lines soon followed, including those to Kew, Hawthorn and Toorak.

Also in the 1880s, Melbourne saw a resurgence of the steam train which had stood still since the mid-1850s. The government-owned Victorian Railways took over the suburban network from the struggling private rail companies.
Turn of the century: the motor car makes its debut

For more than two decades, the combination of trains, trams and horses provided Melburnians with an efficient transport system — within the city and out into the suburbs and rural towns. However, towards the end of the 1800s, the motor car made its debut on the city streets, setting off the urban dilemma which has since vexed Melbourne.

The first motor car wound its way through Melbourne’s main streets in 1897, cruising at 15 kilometres per hour. In 1900, a handful of men, mostly doctors and wealthy professionals, owned cars. As new, faster models were introduced, the number of motor cars on the road steadily increased. But so did the number of speed-limit infringements and the number of motoring accidents. In a repeat of the lethal road accidents caused by the horse cabs in the topsy turvy 1850s, significant numbers of pedestrians were now being killed, this time by over-excited motorists.

In 1908, the Australian Motorist, the bible of motor car enthusiasts, commented that motor cars ‘should be given special roads of their own to run and not be allowed on main roads.’ The statement was seminal. Says Ken Ogden, one of the authors of the Victorian Government’s 1996 transport strategy, Transporting Melbourne, and now director of public policy for the Royal Automobile Club of Victoria (RACV): ‘Because of the motor car, Melbourne’s transport system has grown as if there were two different cities superimposed on each other.

“The basis of Melbourne’s public transport system, its fixed rail, was in place by the 1890s. At that time, we had a transport system and land use that were compatible — with most activity in the centre of the city; a public transport system radiating out from it; tidal commuters moving in and out each day; and tram lines servicing linear shopping centres. It’s all still there, and it still works.

“But superimposed on that is a different sort of city, a modern city, which is based on the motor car — and a high level of auto-mobility — where origins and destinations are not necessarily tied to the public transport system. That city works well, too.

“And where these two come together, in the inner-suburban area and surrounds, you have traffic using a road network that simply does not have the capacity to take it.”

By the 1920s the explosive growth of the use of motor vehicles was creating traffic congestion. This was
because most of the city’s workforce was based in the suburbs, and they wholeheartedly embraced the use of the motor car. As a result, about one trip in five in the greater Melbourne area began or ended in the inner city, and more than half of all journeys ran through the inner city.

Foundation of the freeway system

In 1929, the Melbourne Plan of Town Development was drawn up. This far-sighted document laid the foundation for the system of freeways that now snake through suburban Melbourne. The original document outlined a series of land reservations which have since been used, the land being set aside for decades in the form of power line easements or along creek and river valleys. Thanks to the foresight of this plan, freeway construction in Melbourne has required relatively little demolition of domestic or commercial property.

After the Second World War, Melbourne had become a New World city, heavily dependent on motor vehicles. New arterial roads were constructed in the outer suburbs, but the system still focused on the city centre. The new roads were broad and free-flowing, but the more roads were built, the more traffic increased.

By the 1960s, the government of the day had been advised to build an extensive freeway system. A tentative start was made with the opening of a four-lane strip of the South Eastern Freeway along the edge of the Yarra, from Punt Road to the MacRobertson Bridge in Burnley.

Melbourne, however, never really accepted the full-freeway concept proposed by its American consultants. “Successive governments were finding that extensive freeways were unaffordable, and that the concept would destroy half of the city,” says Dr Lay. “The freeways we now have are modest both in number and geometry.”

Freeways: funnelling traffic into the city

After the South Eastern Freeway came the Tullamarine Freeway in 1970, followed by the western part of the West Gate Freeway, the Calder Freeway, the Mulgrave Freeway and the Eastern Freeway. But it was the opening of the West Gate Bridge, a major crossing over the mouth of the Yarra south of the CBD that began the pressure which finally led to the idea of CityLink.

“The South Eastern Freeway was built in the wild expectation that if you dumped all that traffic onto Punt
Urban dilemma

The Sydney Harbour Tunnel was one of the first Build, Own, Operate and Transfer projects in Australia.

Road, it would somehow find its way after that,” says Dr Lay. “It was a similar expectation for the West Gate Freeway. The Lower Yarra was the natural place for a bridge, but what did you do with the traffic once you had funnelled it into the CBD?”

And so it was that all these unconnected freeways were depositing unprecedented volumes of traffic into the CBD. The freeways were linked by residential and city streets, which were handling traffic volumes up to 80% greater than their capacity.

The necessity of linking up the freeways in order to bypass the CBD has long been recognised by successive State governments. But no matter how one looked at doing it, the cost would be massive. Despite the necessity, the government’s coffers could not underwrite the undertaking. The intent was there, but it was stored in the too-hard basket.

CityLink: the time is ripe

The Sydney Harbour Tunnel was one of the first Build, Own, Operate and Transfer (BOOT) schemes in Australia. As head of Transfield’s Project Development Group, he was feeling a sense of personal pride that the company had successfully arranged financing, as well as developed the project.

The moment he reached the end of the tunnel — the idea hit him — that the BOOT scheme might be the answer to the financial obstacle to linking Melbourne’s disjointed freeways, an idea that was first mooted in the 1929 Town Development Plan. Always on the lookout for business opportunities for his company, Shepherd had been aware of the traffic and financing dilemma that Melbourne faced. By the time he reached his office desk, he had already plotted a preliminary study to determine if a freeway link was technically and financially feasible. “We liked what we saw — it was big and complicated but we could make it satisfy the need,” Shepherd said afterwards.

The time seemed ripe for CityLink. Shepherd took the BOOT idea to Melbourne, enlisting the help of Transfield executives in the city. They took it to the Committee for Melbourne, a private, non-profit organisation that draws together Melbourne’s business, academic and community leaders who take pride in their city. The Committee
arranged a presentation to the then-State Labor government. Thus started a long, involved road show to persuade Labor ministers of the merits of a privately financed infrastructure.

It was a huge task at the time. The Labor government was philosophically opposed to privatisation, but was prepared to give it a run as a private sector project. Eventually, it directed VicRoads to call for expressions of interest from companies on a BOOT basis.

Vision was one thing, but to make the freeway link a reality, technology was also crucial. In this case, it was tunneling technology. Any realistic scheme to take traffic around the south end of the city centre, and out to the south eastern suburbs, simply had to involve tunnels. There were too many obstacles to do it any other way. These obstacles were areas and facilities that were too close to the hearts of Melburnians and were too sensitive to touch: the King’s Domain, the Botanic Gardens, the city’s major entertainment and sporting complex, and the historic suburb of Richmond.

And as Shepherd may have been thinking on that day driving through the Sydney Harbour Tunnel, advances in technology had made tunneling considerably cheaper. Although it was going to be expensive, connecting the freeways was beginning to look as if it might be economically feasible.

---

Chapter 2. The groundwork: hurdles and breakthroughs

City bypass: a private affair

It was late autumn in 1992 and the rain was pelting furiously on Melbourne. At around 8:30 that morning in May, the city exits of the three major freeways were ferociously clogged. Stuck on the South Eastern Freeway was the traffic reporter for one of the radio stations, feeding her regular beat report to the studio.

Today her report was slightly more animated. Because of the heavy rain, cars were backed up two kilometres, instead of the usual one kilometre, from the freeway exit. This had provided variety to her daily grind on Melbourne’s major freeways, which were sometimes referred to as ‘the giant car parks’.

One of those tuned in to the station was David White, Minister for Science, Industry and Technology in the Victorian Labor government. He was checking the final details of an announcement he was due to make, on what he hoped would be the final solution to traffic congestion in inner Melbourne. Later that day, he would be standing on the northern bank of the Yarra River to call for expressions of interest to connect Melbourne’s three major freeways: the Tullamarine Freeway in the north, the West Gate Freeway and the South Eastern Arterial Road (now called the Monash Freeway).

The freeways all terminated on the fringes of the city, causing gridlock as they disgorged tens of thousands of vehicles, especially at peak hours. But in the 1990s, people wanted to travel from north to south, or from east to west of the metropolis - without necessarily going through the city. Indeed, David White had been confronted by crushing traffic statistics. At the city end of the West Gate Freeway around 130,000 vehicles entered and exited each day, the Tullamarine Freeway had 112,000, while the South Eastern Freeway had 90,000.

Half of the traffic in the inner city did not actually want to be there. It was just passing through. Linking the three freeways would allow these non-city-bound vehicles to bypass the city, creating a freer flow of traffic. The government had long recognised this, but at an estimated cost of $2 billion, did not have the means to do it. Victoria was languishing in deep recession, the coffers were empty and the government was borrowing money just to meet its basic expenditure.

It was only in the late 1980s that the bypass had become a realistic solution. There was a growing trend towards privately financed roads. While the Labor government was initially wary of devolving responsibility for essential
The environmental assessment process

At the request of the State Labor Government under Premier Joan Kirner, VicRoads invited Registrations of Interest to develop the Western and Southern Bypasses as a BOOT project in April 1992. In June 1992, the Government also directed VicRoads to prepare an Environmental Effects Statement (EES) for the projects. The study team, led by Bob Evans, worked with a Consultative Committee appointed by the Government.

The study team was supplemented by 20 specialist consultants and received inputs from a range of government agencies. The team attended over 200 meetings with the Consultative Committee, interest groups, councils and other stakeholders. The consultations raised a range of issues which led to further investigations and enhancements to the concepts under investigation.

Following the election of the Kennett Government in October 1992, the developer selection process was put on hold pending a review of the project, but the EES continued.

Options were developed by the team from ideas formulated in earlier planning studies; for example, a tunnel system similar to the Domain and Burnley Tunnels was proposed in the 1954 Metropolitan Planning Scheme. The ideas were further developed both from within VicRoads and from the public consultation process. The assessments favoured the upgrading of the Tullamarine and Monash Freeways, and proposed various options for the Western and Southern Bypasses.

The EES was completed and exhibited in August - October 1994 and submissions were invited. A public hearing was held by an independent panel in November - December 1994. The panel’s report and the assessment of the Minister for Planning were released in April 1994 just before the announcement of the preferred developer, Transurban, in May 1994.

October 1992 State election, the project was put on hold as the new government ordered an exhaustive review.

Under the review spotlight was the BOOT system. Some in the new government wanted a closer examination of the system – private consortiums had financed, built, and were managing major toll roads in Sydney, but Melbourne had not managed any significant BOOT projects. The new government was also anxious about toll roads in general, as Melbourne’s experience with them had not been
The groundwork

Among the financial issues was the issue of State government borrowing. Although the project was envisaged to be privately funded, the State would still need to raise some money to fund the government’s share of the risk under a BOOT project. But to do this, the government had to abide by the guidelines of the Loans Council. The Council, composed of the Treasurers of the Federal, State and Territory governments, in the 1980s regulated each government’s annual borrowings.

In 1992, the Loans Council process did not make allowances for private sector funding of public infrastructure. At that time, all loans to finance a public infrastructure project were deemed to be ‘government borrowings’, and thus within a State’s or Territory’s borrowing limits. In the case of the Western and Southern Bypasses, for example, private sector borrowings for the project would have been considered by the Loans Council as part of the Victorian government’s borrowings. The required amount would have been way beyond the allocation for Victoria.

The second issue was tolling. The private sector would finance and build the project, but it would need tolls as a revenue source. The previous Labor government had mooted the idea of shadow tolling, in which the government would pay the builder-operator the equivalent tolls for the actual number of vehicles using the road. The new government was not very keen on this system as it believed that in this case, it would bear the risk of road usage. So the review panel had to grapple with other ways of collecting tolls.

Cash tolling was an impracticable option: toll plazas took up large tracts of land, and the cost of land acquisition for an urban tollway would be prohibitive. Toll plazas also required vehicles to slow down. This would have defeated the aim of improving the flow of traffic.

Electronic tolling was an attractive option, but this was 1992 and electronic tolling technology was still in its infancy. At the end of 1992, the panel still had no answers to these issues, but had shaped them enough to make a report.

The initial hurdles

The panel soon became convinced that the project was commercially viable and would deliver significant economic benefit. However, there were a number of issues that needed to be addressed, including financial issues and tolling.

encouraging. When the West Gate Bridge was opened as a toll road in 1979, usage was well below expectations, and tolls were discontinued in 1985. As soon as the tolls were withdrawn, usage increased by 40%.

Within three weeks of winning the election, the government created a special panel to review the physical scope, financing and economic aspects of the project. The panel was led by Howard Ronaldson and Dr Alf Smith. It was Alf Smith who would see the review through to its completion, and would become a pivotal figure in defining the State Government’s final position on the project, particularly the desired economic, engineering and environmental outcomes. He would also become one of the few people to see the project from its pre-feasibility stage, through the contract negotiations, during the groundwork and construction, and to its completion.

The initial hurdles

The panel soon became convinced that the project was commercially viable and would deliver significant economic benefit. However, there were a number of issues that needed to be addressed, including financial issues and tolling.
The breakthroughs

The review panel finished its work in January 1993, but the unresolved issues of electronic tolling and borrowing limits delayed the Coalition government’s decision until a year later. Nevertheless, the government maintained the panel to act as a project group, which continued to explore financial options and monitor developments in tolling technology.

The first problem was resolved in late 1993 when the Loans Council system was amended. If the private sector was involved in a public infrastructure project, an appropriate risk weighting was developed so that the State’s borrowing limits would apply only to loans that supported the government’s share of the risk. This change removed a major impediment to the project proceeding.

The crucial breakthrough occurred in February 1994, when both short-listed consortiums approached the project group to say they were prepared to have a go at electronic tolling. By then, the outlook for electronic tolling had changed dramatically. Some countries in Europe and North America had begun experimenting with hybrid electronic tolling systems, including one where some lanes collected tolls manually while others were electronically tolled.

The developments were being driven by some European and US defence companies which, after the collapse of the Cold War, were exploring alternative applications for their technologies, including tracking technology.

The project group concluded that it had found a circuit breaker, and recommended that the Southern Bypass and Western Bypass Project proceed. The project was now truly off and running. The Cabinet accepted the panel’s recommendation in May 1994 and in July, the then-Premier of Victoria, Jeff Kennett, announced that the Project would go ahead with a scheduled completion date of 2000.

When the project brief was issued in September 1994, one particular item stunned the tenderers: the tolling system must allow vehicles to maintain freeway speeds.

At that time, the challenge was more than a little frightening. There was no system anywhere in the world that could collect tolls without vehicles having to stop or slow down. If the two short-listed consortiums wanted to win the project, they would have to be prepared to develop cutting-edge tolling technology.

In retrospect, the government was accurately forecasting the future of tolling technology. But the bidders had good
The groundwork

The groundwork

Although the hardware - which was then in its embryonic form - eventually delivered outstanding performance, the software package was to cause a lot of heartaches and headaches (Chapter 5 discusses the tolling system in detail).

A critical delay

According to Alf Smith, the delay in deciding whether or not to proceed with the project was critical in shaping the framework for CityLink, both physical and financial. It enabled the government to get a better grasp of BOOT requirements and procedures, and importantly, of the private sector’s management culture.

After the review panel’s work, the State had a clear idea of what it wanted the private sector to do, and how to do it. However, it was not sure if what it wanted was within reasonable bounds of standard practice and expectations within the private sector.

Consultations with the two short-listed bidders - which through the review continued to lobby the government to proceed - gave the State greater confidence in the project.

“If the government was to ask the private sector to undertake the project, it needed to set a very clear framework - the desired outcomes and how the outcomes should be achieved. We took a long time to set the right framework, but it sent a clear message that the government completely understood what needed to be done in terms of financing, design, construction and operation. There’s no wasting of the private sector’s time,” Alf Smith said.

As soon as the government decided to proceed, it created a Southern and Western Bypass Coordination Team to draw up the final route option and the project brief. This team would eventually become the core of the Melbourne City Link Authority (MCLA), which would manage the tender process and oversee the project on behalf of the State (see box on the MCLA).

The project brief developed by the Team was considered too prescriptive by the bidders. For example, the physical scope was expanded to include major improvement works to the existing freeways. These included the widening of the Tullamarine Freeway from three to four lanes in each direction; and the widening of the Monash Freeway to three lanes in each direction. The physical changes were specified as the panel recognised that access and an unimpeded traffic flow were critical to the usage of the CityLink, and thus to the economic viability of the project.

While the tenderers may have considered the brief too prescriptive, Alf Smith believed it was as good as it could get. It did have a list of prescribed elements, but this list was only short. “If we had issued the brief in 1993, it would have been a very long document, reflecting the uncertainties on the part of the State. During 1993, government thinking had developed to the extent that it was confident that the must-haves were deliverable,” he said.
A measure of this confidence was that the project brief was in fact an offer document. If a fully conforming bid was accepted, the project would definitely proceed. Before CityLink, bids may have been received for projects that in the end were abandoned by the government.

In hindsight, what the government was doing during 1993 was setting the benchmarks for the private sector to take over responsibility for building and operating public infrastructure. CityLink was going to be the first BOOT project in Victoria, and the government had no precedents to use as a guide.

The MCLA may have been aware that it was setting benchmarks in Victoria, but what it did not know then was that, in subsequent negotiations with the bidders, it pushed the boundaries of private sector responsibilities under BOOT projects in Australia.

The MCLA: Kick starting the project and protecting the public interest

The Melbourne City Link Authority had its beginnings as the Southern and Western Bypass Coordination Team, established by the State Government when it decided to go ahead with the project in May 1994. Its initial task was to determine the final route options and develop the project brief. The Team was led by Dr Alf Smith and Ian Withell, with Ken Mathers representing VicRoads, to look after route alignments, construction costs and the environmental effects studies.

Following the substantial input to the project brief by then Clayton Utz lawyer, John Walter, the brief was issued in September 1994, and a single purpose organisation, the Melbourne City Link Authority was established in December 1994. A group of senior public servants was hand picked for the Authority with Richard Parker as its Chief Executive and John Laurie as Chairman of the board, with other board members drawn from the private sector.

The Authority’s immediate brief was to get the project going and to assess and recommend to government, the preferred bidder. Among the high standards of practice adopted by the Authority in its dealings with the two bidders was the presence of an independent auditor to ensure probity during discussions with bidders and during the tender assessment period. John Matthews from Deloitte Touche Tohmatsu was selected to provide this service and ensure that the processes were fair to each bidder.

Throughout the tender process and afterwards, the Authority has been meticulous not only in maintaining the confidentiality of the bid discussions but also subsequent negotiations with contract parties. The security arrangements worked so successfully that until the day in May 1995 when the tenderers were advised of the result, neither had an inkling of who had won the bidding. This was a phenomenal achievement, given the high level of public and media interest in the project.

The Authority’s role was pivotal to the project at every stage in a number of respects. To proceed, the Authority had to manage a whole new legislative package. At the time, the Melbourne City Link Act 1995 was the single largest piece of legislation ever brought before the Victorian Parliament. Another key task was to acquire all the land needed for the project. Hundreds of parcels of land were acquired and consolidated. This was achieved with minimal disruption to business and the public. Twenty-two kilometres of freeway through the heart of the city generates local issues every step of the way. The Authority played a key role in the interface between the project and the community. In making it happen, the Authority had to smooth the way with up to 36 public bodies intersecting with the project. As the project proceeded, the Authority was required to negotiate variations, including the major addition of the Exhibition Street Extension.

At all times, its charter was to facilitate the project but protect the community interest.

At the start of 2002, the Authority ceased operation and the Government established the new Office of the Director, Melbourne City Link to manage ongoing issues in the interests of the community. The Office is composed of a core group that has been closely involved in the project from its early days.
It was an autumn day in 1995, three years after the first call for expressions of interest in building the CityLink. Melbourne had put on a clear, crisp and sunny day for the announcement of the winning bidder. Outside the offices of Freehills, Transurban’s legal team, on Collins Street in the CBD, the plane tree leaves were displaying their cheerful autumn hues. But inside, a pall of dejection had fallen over three of the architects of the consortium’s bid: Tony Shepherd, Kim Edwards and Shigetaka Sano.

The three, along with their legal and financial advisers, John Curtis of Freehills, and Michael Carapiet of Macquarie Bank, had just heard that the CHART Roads consortium had been called in first by the MCLA to be told of the bidding result. The five men had the sinking feeling that when it was Transurban’s turn to be called in, it was just to confirm the media ‘leaks’ that CHART Roads had won.

Shepherd, Edwards and Sano could therefore hardly contain their emotion when they were called in and told that Transurban had been selected as the preferred tenderer. Shedding their inhibitions, they let out a peal of jubilation when MCLA Chairman John Laurie told them the good news. It is doubtful whether they heard everything that Laurie said about why their bid was selected - they had an aching desire to reach for their mobile phones to call their colleagues.

One of those they didn’t have to call was John Curtis at Freehills. As John Laurie and the MCLA team were walking them to the Premier’s office for a press conference, a group of young Freehills lawyers caught sight of them as they went past the back of the Freehills building. By the body language of Shepherd, Edwards and Sano, they knew Transurban had won.

The Transurban team allowed themselves a day’s euphoria. But the implications of the victory were not lost on the architects of the bid. They knew they were entering uncharted waters.

CityLink was the largest engineering project Australia had seen since the Snowy Mountain Hydro-Electric Scheme, and its sheer scale, technical complexity and overall ambition were going to present a paramount challenge to the engineers. As well, the price tag of $2 billion made it the single largest public infrastructure project that Australia’s financial market had ever seen. This posed a monumental challenge to the consortium’s fund raisers. CityLink would also set an international milestone: it would feature a fully automated tolling system which was untried anywhere else in the world.

All these factors turned the team’s jubilation into trepidation.

On all fronts – engineering, financial and tolling technology – Transurban had a chance, which only came once in a generation, to set a milestone in Australia’s infrastructure history. What it would accomplish would serve as a benchmark for years to come.
Tender preparations

The enormity of the project had been apparent earlier, when the tender was being put together. With only four months to satisfy the requirements of the minutely detailed project brief, Transurban pulled together over 200 people to be able to submit the bid on time. Besides the requirements on engineering design and standards, the project brief also specified urban design and aesthetic requirements, as well as environmental parameters.

Importantly, the brief required firm financial commitments from the bidders’ debt and equity providers. This meant that tender preparations required legal work to an extent never seen before in infrastructure tendering in Australia. At least four sets of legal documents were required by the brief: binding commitments from all consortium members for sponsor equity; formal legal agreements with contractors for design, construction, operation and maintenance; agreements with financiers to accept the provisions of the project brief, particularly those relating to risk allocation; and underwriting agreements from investors providing debt and equity for the project.

Transurban’s legal team from Freehills, led by John Curtis and Jim Theodore, ultimately had to draw up around 120 sets of contractual agreements. During the tender phase, the core legal documents and associated offer documents were being finalised right up to the last moments before the deadline. The documentation requirements were so massive that during the last two weeks of tender preparations, the consortium’s in-house printing shop was running 24 hours a day, and staff were falling asleep next to it.

Transurban’s tender documents were finally presented in two especially designed and built filing cabinets.

The MCLA’s Alf Smith recalled that CHART Roads’ documents were delivered at lunch time, but Transurban’s arrived five minutes before the bids were due to close. “We later learned that the documents were being assembled in the truck on the way to us,” he said.

The MCLA’s bid assessment team wasted no time, and that night started wading through, and absorbing, the proposals.

Two months later, the MCLA sought to clarify certain aspects of both bids, not the least the financial structures and the risks to be borne by each of the parties to both consortiums. It also wanted both groups to minimise the tolls to be charged. It then asked them to revise their bids.

In the next three weeks, both the State government and the tenderers went through serious re-assessments of their respective positions. By the time the revised bids were submitted, each consortium had spent nearly $20 million.

And while Transurban won the bid to become the preferred tenderer, this was just the beginning of its long hard toil in negotiating with the State and with the consortium members. In fact, the CHART Roads consortium was held on ‘active reserve’ status until the satisfactory conclusion of engineering, legal and financial agreements between Transurban and the State.
The contract

New boundaries for private sector risk

CityLink will go down in Australian engineering history as having pushed the boundaries of risk allocation, with Transurban taking on risks previously never accepted by the private sector in infrastructure projects in Australia.

The State had decided that the project would proceed on a BOOT basis, and it expected to be able to push almost all of the risk to the private builder. As Freehills’ Jim Theodore observed: “Any private bidder would have understood that in order to win, it would have to accept the new risk levels. If the government were to take on these risks, it might as well build the project itself.”

Indeed, risk allocation was at the core of the protracted, highly emotional and sometimes acrimonious negotiations required to arrive at the Concession Deed, the principal agreement between Transurban and the State government, as represented by the MCLA. It took the whole of five months before the parties signed the Concession Deed, and then only because of the intervention of the Premier, Jeff Kennett.

By all accounts, much of the time spent in negotiations focused on events that were highly unlikely to occur. As Tony Shepherd put it: “We were spending 99% of our time discussing events that had 1% probability of happening.” However, these events could have a staggering impact on Transurban’s massive financial exposure.

One of the most difficult issues was Government guarantees over a long time frame. Somehow, the State’s unfettered right to change laws had to be reconciled with the consortium’s having assurances that any new laws did not prevent it from implementing the project, or did not adversely affect its ability to repay its debt.

Government Ministers appreciated the extent of the chasm between the State’s and the private sector’s position, and gave negotiators unparalleled access. The Premier; the Treasurer, Alan Stockdale; the Minister for Major Projects, Mark Birrell; and the Minister for Roads and Ports, Bill Baxter, kept particularly close tabs on the negotiations, and gave unparalleled access to MCLA officers.

The 10-day ultimatum

The demands of the consortium’s debt providers were the last, and biggest, hurdle to signing the Concession Deed. The banks, among all the parties to the consortium, found it most difficult to accept the new levels of risk that the State was pushing on to the private sector. The banking syndicate was insisting that the State provide a guarantee of returns during uninsurable events such as natural disasters and Federal Government policy decisions that might affect project returns. It also wanted to be compensated for future State Government decisions that might affect the profitability of CityLink. For example, the State or a State agency could build new, parallel roads that gave motorists cheaper alternatives to the CityLink.

The message from the banks was clear: no State guarantees, no financing. But the message was also clear from the State: it would not give ground on private sector risk. Transurban, its legal and financial advisers were caught between the proverbial rock and a hard place.
The banking syndicate had unmatched bargaining power. Transurban’s bankers included all four major Australian banks: ANZ, Commonwealth, National Australia Bank and Westpac. Transurban had nowhere else to turn for alternative financing. “We felt powerless. All we had on the table was a take-it-or-leave-it proposition. We were trapped, and everything seemed to stand permanently still,” said Kim Edwards.

It was the intervention of Jeff Kennett that provided the circuit breaker in what Tony Shepherd described as a three-dimensional chess game. Having heard of the stand-off, Kennett would occasionally make a surprise appearance at the negotiations to coax agreement on one point or another. As Kim Edwards would recall, “Kennett, at one meeting, rocks in very late at night, sits at the head of the table and says: ‘Well come on, we can all play poker and you can now throw your cards on the table.’”

On October 10, 1995, in a bold act of brinkmanship, the Kennett Government issued the ultimatum: the parties had 10 days to agree on the Concession Deed, otherwise the deal was off. CHART Roads would be called upon to have a go at the project. No one thought it was an empty threat.

The 10-day ultimatum had created a flurry in the Transurban camp. Key negotiators were moved to the Freehills headquarters on 101 Collins Street, while the banks rented premises across the road. In the next ten days, Level 48 of 101 Collins Street was transformed into a hub of negotiations, where everyone present understood that failure meant not only the loss of the $20 million spent on bid preparations. It would mean the loss of an opportunity that would never come their way again. Professional pride was at stake.

Twenty-four-hour working days, the smell of pizzas and greasy take-aways became the norm during the next ten days. Arguments became louder and heated as stress took its toll. Yet deep personal friendships also began to form during two-hour respites at dawn, before buckling down to yet another harrowing day of negotiations.

Still, the banks were not giving in. Neither would the State budge from its position.

Without precedents to guide them, both the MCLA and Transurban groped their way forward. As Transurban’s Ken Daley observed: “No one around the negotiating table, neither the MCLA nor Transurban had any parallels to draw on. There were great demands and we were all playing for high stakes. There was a buzz, and it took guts and drive.”

In the end, the banks capitulated. They agreed, together with Transurban, to accept most of the risk from uninsurable events and from State and Federal Government acts, including the construction of a rail service.

While the rest of the CBD slept, Level 48 of 101 Collins Street was the hub of night-long negotiations to achieve financial settlement with the banks.

(Photo courtesy of the Age)
passenger link between the city and Melbourne’s Tullamarine airport.

Many in the group likened the ten days of negotiations to a war. “It brought out the best and the worst in people. And as in any war, there are victors and there are casualties,” said Tony Shepherd.

For some, the casualty was personal relationships, especially with families. Jim Theodore, then a young, newly married lawyer from Freehills, felt he had spent two years of his marriage on the intense work, from bid preparations to financial close. John Curtis saw his son being born, but did not see him awake again until after six months.

For some, the casualty was personal health, with some members of the negotiating team from all sides needing to be hospitalised. The emotional and mental pressure of getting agreement from a fractured group weighed heavily on the key negotiators, who were functioning on very little sleep.

Yet, as in any war, from the carnage and casualties emerge friendships and shared moments of humour – such as the stormy, blustery night when two negotiators became desperate to have a quick smoke. Loath to go out into the cold and wet, they searched for a room with a large ventilation air intake, then took turns puffing smoke into the vent. Not many words were spoken, but the seeds of a mutual appreciation had been sown.

And as Tony Shepherd said: “You’ll always remember the people who were with you at two o’clock each morning, still going strong and maintaining their courtesy and sense of humour. These are the people you’d want to be your friends and colleagues in years to come.”

In hindsight, everyone involved in those 10 days of war agreed that it was an unprecedented negotiation, and felt uniquely privileged to have been part of it. “We all gained a lot of grey hair, but we also gained experience and knowledge that come very rarely. I don’t think there will be many more projects that will give people the same quality of negotiations such as this,” said Michael Carapiet of Macquarie Bank.

For Alf Smith, the defining lesson of the whole negotiation was the importance of managing relationships among different parties. “When people are negotiating for very high stakes, there is always the real potential for a breakdown. In this instance, the parties pulled through, not the least because of the emphasis placed on maintaining the communication and managing the open relationships.”
## The long road to a deal

**1992**
- **May**: Labor Government calls for expression of interest to connect freeways, with project officially known as the Western and Southern Bypasses
- **September**: Shortlist of two bidders announced
- **October**: Newly elected Coalition Government puts project on hold and announces project review

**1994**
- **May**: Government decision for project to proceed
- **July**: Premier Jeff Kennett announces project will go ahead, with the year 2000 as completion date
- **September**: Project brief issued to the two short-listed bidders

**1995**
- **January**: Deadline for bid submission
- **March**: Bidders asked to revise their submissions
- **May**: Transurban announced as preferred consortium, CHART Roads placed on ‘active reserve’
- **October**: Negotiations stalled between Transurban and the State, represented by the Melbourne City Link Authority

**10 October**: Coalition Government issues ultimatum that State will re-open negotiations with CHART Roads if agreement is not reached

**20 October**: Transurban and the State sign Concession Deed

**1996**
- **March**: Financial close with equity and debt providers
- **May**: Official ground breaking for the project

**1999**
- **August**: Western Link opens to traffic

**2000**
- **April**: Some sections of Southern Link open to traffic
- **December**: CityLink fully open
Every day since 1996, Rina Vardouniotis strolls to the end of her street to tend the olive trees and a small vegetable patch on a small pocket park known to locals as Rina’s garden. It was where her old home once stood: at the end of Mary Street in Richmond, near an old power sub-station. She now lovingly inspects the slender leaves of the young olive trees, pulling weeds in the garden and turning the soil with compost, as if hoping, by some miracle, that the small brick home will sprout back into existence.

Rina and Fotis Vardouniotis’ property was one of the private residences acquired by the MCLA for the CityLink project. The couple’s neighbours, acutely aware of their emotional state, had consulted the MCLA and the construction contractor, and after exploring different suggestions, the olive trees were planted in recognition of the couple’s Greek heritage. By early 1999, the small trees had began to bear fruit, which Rina harvests and processes in her new home not far away from the garden.

For a project of CityLink’s size – involving 22 km of new roads – the effect on private land holdings and residences was remarkably small. This is because the Southern Link is almost entirely underground, while for the Western Link, most of the land requirements were Crown land or land owned by government agencies. For the whole project, only 17 private residences were acquired, seven of which were in one block of units.

Nevertheless, the residents’ desire to ‘have a say’ was intense. CityLink was going to be a tollway and emotions were understandably high. Open and transparent community consultation was thus hugely critical at every stage of the development of CityLink. Indeed, the Vardouniotis’ olive garden is just one manifestation of the outcome of consultation, as are some significant design changes that have since become the aesthetic symbols of CityLink.

Land acquisition started in earnest after the project’s financial close in March 1996, when all the financial documents had been signed and sealed. The closure was like a starting gun for a race: all the money committed by investors and debtors could now be released, and the first stone of CityLink could be laid.

Community consultation

Land acquisition, along with community and stakeholder consultations, were the crucial first steps in the implementation of the CityLink project. Indeed, the project’s Environmental Effects Statement (EES), which was prepared long before the tender went out, was
prepared in consultation with interest groups, government departments, statutory authorities, local councils and individuals.

The contract or Concession Deed signed in October 1995, which sets out the basis on which the project was to proceed, provided for consultation with affected municipalities and community groups on architectural features of CityLink, such as noise walls and landscaping. This was known as the Schedule 5 process, under which all affected municipalities were given details of the proposed design. Notification was also given on where design plans could be inspected by the affected public. Individuals and groups had 20 working days to consider the plans and make written submissions to the MCLA. The submissions were then discussed between the MCLA and Transurban for appropriate action.

The plans were advertised in metropolitan and local media and summarised in leaflets that were sent directly to local residents. They were also displayed in community venues such as council buildings and libraries. Community information nights were held in centres near anticipated construction sites, with engineers, health and safety officers, and community relations people from both the MCLA and private contractors fronting up to meet anxious – and sometimes angry – residents.

A common issue raised by the community throughout the consultations was the noise arising from the building of new freeways and the expansion of existing ones. Almost 80% of submissions under the Schedule 5 process raised concern about the noise walls, particularly their appearance, the ‘overshadowing’ they might cause on some houses, and their effectiveness in reducing noise levels in residential areas.

The effectiveness of the consultation process may be measured by the design changes negotiated by the community groups. In the western section for example, the State paid for about 1,300 square metres of transparent panels that were erected in locations where homes would otherwise be seriously overshadowed by the walls. In parts of the southern section, transparent panels were used on the topmost side of the noise walls, instead of building five-metre solid concrete walls.

In both sections, native shrubs were planted against the full length of the walls, adding visual depth and reducing the effects of the imposing mass.

Some of the changes resulting from consultations were more fundamental. An example was the construction of the tunnels along Grant Street. The original plan would have resulted in a long closure of Grant Street. A submission from the Victorian College of the Arts asked if it was possible to keep disturbance to a minimum, and as a result, the tunnel builders resorted to a modified cut-and-cover method. Under the conventional cut-and-cover method, a trench would have been hollowed out, a concrete canopy placed over it and fill put on top. What actually transpired was that, first, rows of holes were drilled to bedrock along either side of the proposed carriageways to allow concrete columns or piers to be cast in place. Once these piers were set, a deck spanning
The momentum builds

The scoreboard for final confirmation that their team had won – or lost. It was a nerve-racking game: until the last three minutes, neither team had the edge.

But the scoreboard seemed on the blink. It went blank for four seconds and when it flashed the final scores, it simultaneously flashed the words: CityLink works - From 8 PM today, Grant St closed between St Kilda Rd and Sturt St.

It was early May in 1996 and construction of CityLink was to begin at three sites: Burnley, South Melbourne and Richmond. Transfield Obayashi Joint Venture (TOJV), Transurban’s design and construction contractor, had launched a saturation information campaign to inform motorists and the public of traffic diversions and delays. The obligatory media were used, but the MCG scoreboard was to become an important part of traffic bulletins for the duration of the construction. Hosting three Australian Rules football games during weekends, each with an average attendance of 50,000 people, the MCG was a publicist’s dream in terms of audience reach.

Throughout the construction period, community information nights were held to inform residents of the project’s progress and to consult on design changes that were necessary during construction. Importantly, the process was a way of keeping engineers, managers and construction workers immersed in public consultation. There are not many infrastructure projects that are right next door to residential areas, and for many of those involved in the construction of CityLink, it took some time getting used to the constant interaction with residents and interest groups. Nevertheless, the unanimous verdict of the project personnel was that, by incorporating inputs from affected interest groups at each step of the way, there was a greater likelihood the project would proceed smoothly.

Community input was obtained on landscaping and noise wall design.

the area over the proposed roads was set in place using pre-cast concrete elements and founded on the piers. Then excavation took place unimpeded underneath the deck, while the ground surface was reinstated quickly. (Chapter 8 discusses tunnel construction in detail.)

Not only did this allow the Grant Street area, which includes the Victorian College of the Arts, to get back to normal almost two years earlier than expected, but the deck shielded the local residents from the noise of construction.

For Paul Ellis, a Richmond resident who used the consultation process to air his views, the solitary lesson from the process was that residents and businesses directly affected by a project bear the onus of ensuring that community input is taken on board by project proponents. “If you are directly on the path of a project and you don’t seek information, or do not put forward your views and influence the design and processes, no one else will do it for you. We cannot hide behind the catchcry: why weren’t we consulted?”.

Construction begins

The final siren echoed across the MCG (Melbourne Cricket Ground) and in knee-jerk reaction, over 80,000 Australian football fans jumped up – either in exultation or commiseration. They turned their collective gaze on...
The major works

The project consisted of two sections of roadway known as the Southern Link and the Western Link.

The Southern Link joined the West Gate Freeway to the South Eastern Arterial (now renamed Monash Freeway). The work consisted of:

- the 3.4 km Burnley Tunnel for east-bound traffic and the 1.6 km Domain Tunnel for west-bound traffic. These three-lane tunnels pass under the Yarra River and the King’s Domain. The Burnley Tunnel also passes under residential and commercial areas of the suburbs of Richmond and Burnley, and

- the upgrading of the Monash Freeway from the previous four lanes to five or six lanes over a distance of five kilometres.

The Western Link connected the Tullamarine Freeway and West Gate Freeway and included:

- a dramatic upgrading of the Tullamarine Freeway, where the innermost eight kilometres were expanded from the previous four lanes to eight traffic lanes, and

- the construction of a six-lane elevated freeway for the five kilometres between the Tullamarine Freeway and the West Gate Freeway. The Western Link also included a new bridge, the Bolte Bridge, over the lower reaches of the Yarra River.
Organisational links

The Concession Deed between Transurban and the State set out the basis on which CityLink was built and operated.

MCLA was responsible for assessing and clarifying the bids and advising on key engineering issues, and later recommending that the State grant the concession to Transurban to build CityLink. It was also responsible for overseeing construction and for the compulsory acquisition of properties for the project.

Transurban, which is now a public company listed on the Australian Stock Exchange, has a 37½-year contract with the State to build, own and operate CityLink. After the expiry of the contract, CityLink will be transferred to the State Government.

Transurban had entered into a major contract arrangement with TOJV to design and construct CityLink. TOJV itself built the Southern Link, but it had sub-contracted Baulderstone Hornibrook Engineering to build the Western Link. Operation and ongoing maintenance of CityLink, including the operation and maintenance of the electronic tolling and traffic management system, was sub-contracted by Transurban to Translink Operations, a joint venture between Transfield and the French company Transroute. Another joint venture between Transfield and Transroute – Translink Systems – supplied the electronic tolling system.

The MCLA and Transurban jointly appointed an Independent Reviewer to check the quality of construction design and implementation.
The Independent Reviewer

To keep construction on schedule and ensure that each project element was built to specified standards, the Melbourne City Link Act created the role of an Independent Reviewer. The job was put out to tender, and in January 1996 the MCLA and Transurban jointly appointed Sinclair Knight Merz, in conjunction with Parsons Brinckerhoff and Davis Langdon Australia.

Dr Max Lay headed that consortium’s bid and was to become the public personality of the the Independent Reviewer. They could not have found anyone more suitable. As one of Australia’s most prominent and respected road engineers, Max Lay never doubted – even as early as the 1970s – that a city bypass would be the ultimate solution to Melbourne’s traffic congestion.

The Independent Reviewer serves as an inspector for the two key parties: the State government as represented by the MCLA, and the concessionaire which is Transurban. The Reviewer’s role was to ensure all parties kept their part of the agreement, including performance standards. The Independent Reviewer was the body which certified the completion of any work, and it was only upon certification that a payment could be made.

But the way the Reviewer performed its job was a far cry from conventional building inspection. Max Lay: “In the old days in a job like this, you would employ hordes of Government inspectors crawling around with tape measures and weighing devices and probes. We didn’t do any of that. We relied on the builders. They defined their quality processes and did their own inspection and testing. We then audited them: their own and their sub-contractors’ management and quality processes.”

According to Max Lay, this is a unique approach, following 100 years of Australian governments wanting to inspect infrastructure projects at every step of the way.

Max Lay summarises the Independent Reviewer’s role: “We protected all sides. We didn’t only check that the builder was building what it said it would, but we also made sure that the government didn’t get a bright idea halfway through the job and insist that the builder carry it out without due compensation. We also acted as an arbitrator in disputes between the different parties, and approved payments and extensions of time. Ultimately, according to the Melbourne City Link Act, we were the guys who had to say: ‘CityLink is now complete and safe to use. You can open it and collect tolls.’
As the last signature and corporate seal were affixed to the financial documents, the tense shoulders of the chief executives of Transfield and Obayashi visibly relaxed. The furrowed brows gave way to slight smiles among the small core group of project backers that had toiled relentlessly to move the Transurban group’s bid toward a financial close.

Achieving the closure was a protracted and arduous process. After all, it was the most ambitious infrastructure financial package ever put together in Australia. It was a showcase for the then-new funding instruments and concepts developed for large-scale infrastructure projects. Most of the structural elements of the funding had just been tried – particularly to finance Sydney’s M2 tollway – but the size of some of the debt instruments was far larger than the existing market for those instruments.

The total project cost of $1.8 billion was funded with $510 million in equity from public and institutional investors, and $1.3 billion in debt. (An additional $200 million was allocated by the State government for State works such as road improvements, some of the Tullamarine and Monash Freeway modifications, and landscaping.)

Of the $510 million equity, Transfield and Obayashi provided $50 million each. The remainder was raised from institutions, corporate and public investors. Initial equity was raised through an institutional issue worth $206.5 million; direct subscription issue to a select group of institutional and corporate investors worth $185 million, including the $50 million committed by Transfield; and a public issue worth $63.5 million. In addition, there was also a deferred equity of $55 million, paid 45 months after the financial close, and which comprised the $50 million committed by Obayashi and $5 million from Transroute, a Transfield subsidiary.

The debt package consisted of a core $1.3 billion in long-term debt. The $1.3 billion debt consisted of a $1.2 billion-infrastructure loan facility, a project debt facility with 17- and 19-year terms, a $350 million-CPI bond facility, and a $51-million subordinated loan specifically to pay for the purchase of the e-TAGs, the transponders for the tolling system.
Michael Carapiet of Macquarie Bank, Transurban’s lead financial adviser: “Creating an esoteric funding package that will theoretically deliver large benefits may provide some intellectual fun and challenge, but if it makes the bid evaluation authority nervous and no one is brave enough to fund it, it is a waste of time.”

In creating the package, the project’s financial advisers had two critical considerations. First was the need to raise all the funding at the outset to pay for the construction and create the financial certainty required by the State government. Second was the need to efficiently use the tax incentives available to infrastructure projects in order to provide income and security to investors both before and after the toll road started operating.

To achieve both, Transurban broke the project into two discrete phases – construction and operation – and created a risk and funding structure that only makes sense if the project is seen as two sequential developments: those of construction and operation. Transurban’s legal structure was set as a dual company/trust organisation: the listed company Transurban CityLink Limited and Transurban CityLink Unit Trust.

The listed company, whose shares are traded on the stock exchange, raised the massive up-front requirements by borrowing money from financial institutions and by issuing debt instruments such as infrastructure bonds which offer investors significant tax benefits. Through these capital and debt raisings, the company was able to make interest payments during construction, when the project was not generating any income.

After project completion, however, investors would benefit more if the returns were in the form of pre-tax dividends. This was particularly true of institutional investors, whose performances were judged on their gross pre-tax returns. To be able to make pre-tax distributions, the trust structure was a better option for the consortium.

Equity during construction was subscribed by the public and institutional investors in parcels worth $500, comprising 499 Equity Infrastructure Bonds, one share in the listed company, and one unit in the trust. The three securities in each parcel were ‘stapled’ together and could not be traded separately. The parcels were structured this way so that tax-exempt interest could be paid to the Equity Infrastructure Bond holders during construction.

After project completion, all the 499 Equity Infrastructure Bonds within each parcel were automatically converted into a stapled security comprising one share in the company and one unit in the trust. This meant that after conversion, each parcel contained 500 shares and 500 units. Each stapled security continued to be tied together and could not be traded separately. At this stage, returns to investors were – and continue to be – dependent on Transurban’s operational performance, principally on the volume of traffic using CityLink.

The complex legal and financial structuring, however, does not disguise the fact that the success of the project depends simply on the number of vehicles that use CityLink.
Part II

The Technological Dimension
Chapter 5. Electronic tolling:  
the silent force behind CityLink

There were two parallel constructions on the CityLink project. One was the publicly visible physical work: the road works, the building of viaducts and bridges, and the excavation of tunnels. The other occurred in the ‘backroom,’ where dozens of computer and software engineers toiled to develop the electronic tolling system that would make CityLink an international byword in road technology.

Indeed, the CityLink tolling system is pioneering technology. It has software that measures and records every vehicle as it passes each toll point, senses whether the vehicle has a transponder, determines the toll zones the vehicle has traversed on the toll road (which has 17 interchanges), then computes the toll transaction for that vehicle. It collects tolls from multiple lanes without vehicles having to slow down. It talks via microwave frequency to the transponder in the vehicle, senses the vehicle’s registration number, and automatically transmits the toll amount to the vehicle owner’s account for billing.

In 2001, three overseas delegations per month called on Transurban to get briefings on how the state-of-the-art system works. Kim Edwards and Ken Daley always gave the visitors animated presentations on the capabilities of the system, but not once did they betray the agony they went through during the system’s development.

Development pains

“Anything wrong that could happen, happened,” said Ken Daley. “It is an utterly complex system. It was built alright, but when it came to testing the central control system for the first time, its performance failed miserably. For months, the developers spent 14- to 20-hour days checking, redefining parameters, modifying design, tweaking – everything and anything to make it right.”

The roadside system – which includes sensing the details of vehicles on the road – was developed without too much pain. What gave the software engineers their worst nightmare was putting together the Central Toll Computer System (CTCS), which draws together all the information transmitted from the roadside system.

The core problem was the sheer enormity of the information that needed to be processed by the central toll control system – around 600,000 transactions a day, given the estimated 800,000 vehicles that use CityLink.
According to Vin Childs, who helped oversee the system development for TOJV, the system developers had little precedent to follow. The closest benchmark was Highway 407 in Toronto, Canada, which has around 300,000 users a day.

Exacerbating the problem was the structure of the reporting relationship between the road developer, Transurban, and the company that developed the tolling system. Kim Edwards admits that at the height of the problem with the tolling system development, it felt as if Transurban had even less control of the problem than it had in the stand-off with the banks that threatened the financing of the project (see Chapter 3, section on The 10-day ultimatum).

"We thought we were clever in rigorously setting the risk allocation with the banks, but in this case, we had a structure in which Transurban was far removed from the software developers so communication was more difficult. The structure was built around something that we’ve never done before. There was much guessing on how it would work, and what the products would be like," Edwards said.

Viewing the problem from the sideline, MCLA’s John Laurie said: “There is nothing mysterious in what caused the problem. The developers were faced with an enormous amount of data input. If you’re talking about five or half-a-dozen entry points, or less than the hundreds of thousand of vehicles per day that go via CityLink, the problem would have been easily surmounted. But it’s like asking these people to climb a mountain that’s four times higher than has ever been climbed before. The most depressing thing for them was that they had to find a solution – they had no fallback. Manual tolling or part electronic tolling was out of the question because the State Government wouldn’t have a bar of it."

In the end, a workable system finally emerged – several months after the expected opening of CityLink. And even after that, during the first month of operation, there were embarrassing glitches, such as errors in customer billing.

**Why it had to be an electronic system**

Transurban had no choice but to develop an electronic tolling system. The Victorian Government had specified that whatever system was installed, it must not impede the free flow of traffic. Only an electronic system could allow that.

The reason for the Government requirement was simple: CityLink was sold to the public not only as providing reduced travel times, but also as reducing the pollution produced by stop-start driving in heavy traffic. Neither of those goals could have been achieved using conventional toll plazas where cars had to slow down while the drivers paid at a booth.
Electronic tolling

There was another problem with installing toll plazas – land. CityLink is an inner city freeway complex, constructed through areas that have been intensively developed for well over a century. The real estate required to build a toll plaza would have been prohibitively expensive. Moreover, the large number of entrances and exits required – 17 in all – had rendered the idea impractical.

But an electronic tolling system was not without problems. A system that could cope with multiple lanes of traffic at freeway speeds had never been tried before and so posed a paramount challenge to the developers. Highway 407 in Toronto, the closest model, had significantly lower traffic than CityLink’s 600,000 vehicles a day.

Translink Systems, a joint venture between Transfield and the French company Transroute, was contracted for the design, implementation, integration and commissioning of the electronic tolling system and the traffic management system. Supplying Translink Systems with the roadside tolling equipment was Combitech Traffic Systems, then a subsidiary of the Swedish aircraft, armaments and automotive conglomerate, Saab.

Combitech had built single-lane operations in other parts of the world, not multi-lane at freeway speeds. They used Australia as a testing ground for the rest of the world. Between Combitech and Translink Systems, considerable human and financial resources were deployed to get the system right.

Bernie O’Day, Transurban’s commissioning manager for the tolling system, agreed that after all the pain and the innumerable tests, the system was made right. “At the end of the day, everyone agrees it is a tremendous system that will be adopted worldwide.”

Combitech was able to draw on the Saab group’s experience with military hardware in building high-tech warplanes and artillery. The company adapted technology used for aiming guided weapons, and put it to use in recognising and recording vehicles travelling on a freeway.

The electronic tolling system combines remote sensing and communication with the management and storage capabilities of the computer. The system designed and provided by Combitech actually performs several different functions and uses several different technologies. It uses a sophisticated video detection and classification system to detect oncoming vehicles, microwaves to communicate with the e-TAG transponders carried by those vehicles, video cameras to classify vehicles and record number plates, and high-speed computer processing and storage to coordinate it all and carry out the actual tolling function.
The Technological Dimension

Elements of the system

When a vehicle approaches a tolling gantry, it is detected by the Vehicle Detection and Classification (VDC) system which determines the trajectory and the dimensions of the vehicle. The main elements of the VDC are located in the large rectangular hoods that hang out overhead from the gantry. Using a pair of cameras arranged in a stereoscopic manner, the computer system in the gantry combines video images from the pair of digital cameras into a single image of a vehicle. This allows its position, height, width and length to be calculated at highway speeds to within an accuracy of a few centimetres.

In essence, the VDC determines the size of the rectangular box into which the vehicle would fit. Then, using pre-determined limits for the three dimensions, the system sorts vehicles into one of three categories: cars, light commercial vehicles or heavy commercial vehicles. Different toll rates apply to each category.

The images from any two neighbouring cameras overlap, so the system can always have a pair of cameras detecting a vehicle. This means that vehicles do not have to be confined to a particular lane while travelling under the gantry. And several vehicles, even crossing between lanes, can be tracked simultaneously at freeway speeds.

Once a vehicle has been detected, a microwave communication system attempts to make contact with its e-TAG which allows it to be identified. Each e-TAG is linked to a CityLink account. Not all vehicles are equipped with e-TAGs; generally only those which use the tollway regularly.

The e-TAG is a ‘transponder’. That is, it only transmits information in response to a received communication. In the case of CityLink, the e-TAG responds simply by re-transmitting or reflecting part of the message it receives. It also transmits its own unique identification code. This can then be checked by a computer, which determines first, that the e-TAG is valid; second, that the vehicle carrying the e-TAG fits into the category connected with that tag; and third, if necessary, that the licence plate number matches.

The e-TAG had to be designed to work under taxing environmental conditions. For instance, it is only active intermittently for less than a second when it is passing under a gantry. That means that while e-TAGs consume...
almost no power, they need a reliable source of battery power to switch them on instantly when prompted. And they also have to be rugged enough to work under Melbourne’s highly variable environmental conditions, where temperatures inside vehicles can range from below 0°C on a cold winter’s morning to above 70°C on a hot summer’s day. Translink Systems and Combitech worked with a consumer electronics company, NEC Australia, to develop a suitable package based on Combitech’s Swedish design.

While the vehicle detection and classification and the microwave systems are performing their particular tasks, a third system is also at work: the vehicle registration (VR) system. This is another video-based system which takes a photograph, or more precisely, records a digital image of the front of any detected vehicle – at full highway speeds. The cameras for doing this can be seen extending behind the gantry, angled down. Once the image is stored, a clever computer program analyses the image and extracts the vehicle licence plate number.

So, within the space of about one twenty-fifth of a second, the gantry system has assembled four important pieces of information: the time that a particular vehicle passed underneath it, what category of vehicle it was, valid e-TAG identification (if fitted), and its number plate. Importantly, the system can accurately and reliably allocate specific tags to specific vehicles, and identify vehicles without e-TAGS. On the basis of this information appropriate tolls can be charged.

The amount of toll is calculated based on the classification of the vehicle and how far it travels during its trip on CityLink. If the vehicle is equipped with a valid e-TAG, the account linked to that e-TAG is charged with the toll. If an e-TAG is detected which does not match the vehicle in which it is found, then the picture of the number plate is passed on for further action, such as contacting customers to update their account details. Where there is no e-TAG, the licence number is checked against any CityLink Passes that have been issued for that day, and the information is kept until the toll is paid. If the toll remains unpaid, further action can be taken.

The tolling system has been tested to work to a level of up to a million vehicles a day. So the financial consequences of losing the huge amount of information being generated are large – even if the system went down for only five minutes. To avoid a crash, all electronic tolling equipment is ‘dual redundant’. That is, as one piece of equipment is operating (called the hot equipment), a second identical piece of back-up (the warm equipment) is ready to automatically take over in case of a malfunction or failure.

There are three levels of computers in the tolling system. The first two are housed at each tolling point in a concrete bunker known as a technical shelter. At each tolling point, each gantry is separately controlled by an Automatic Lane Controller computer, which coordinates the sensing systems (all of which communicate with each other), and feeds all the information across to the second level of computers: the Tolling Station Management computer. The third level is the Central Toll Collection System computers which are located in the Operations building.

Each gantry is set up as a tolling station in its own right. If a technical shelter loses communication with the central system, the data will be stored within the equipment at the toll point, until the shelter is back online. The data will then be transmitted down the line without loss.
It is in the technical shelters that computers of considerable power carry out the necessary analyses for the VDC and VR systems. Only the information needed for billing and enforcement is sent to the third level of computers, the Central Toll Computer System (CTCS) in CityLink’s Operations and Maintenance Building in South Melbourne. If there is a problem with the CTCS, the roadside shelters have the capacity to store information so that none is lost. What’s more, there are two separate high-speed optical fibre connections with the CTCS, one each side of the tollway. If one fails the other continues to operate seamlessly.

The CTCS builds up a record of each vehicle’s trip, calculates the toll and debits the account. It also performs all the other tasks necessary for electronic tolling, such as account establishment, statements and e-TAG distribution. The CTCS communicates with 14 other computer systems at banks, Australia Post, and the enforcement agency. They all connect through a set of firewalls. The system uses several different operating systems, such as NT, Solaris, Unix, and Forte. They all have to operate independently, but they also have to talk to each other. And that’s not always simple. The major sub-contractor to Translink Systems for the delivery of the CTCS was Computer Sciences Corporation.

The Central Computer Control System

In addition to the CTCS, CityLink’s Operations and Maintenance Building also houses the Traffic Control Room, the nerve centre of CityLink. In this room, the Central Computer Control System (CCCS) puts one operator in control of all the systems of CityLink, including the tunnel ventilation and fire control system; variable message signs and lane-use signals; the power supply systems; communications and motorist emergency telephones; closed circuit television cameras; and air quality monitors.

A freeway computer system of such complexity, which monitors, communicates with, and controls about 6,000 pieces of equipment, had never been assembled before. The CCCS was developed by TOJV, in collaboration with Schneider Electric as design managers, and Motherwell Information Systems for design enhancement and system implementation.

The CCCS brings all the information into operator workstations, each with twin monitors. The operators also have access to closed circuit television screens and two large wallboards that can display information from any of the monitors. The basis of this display is a graphical map. The CityLink control room, with automatic detection monitors.
Electronic tolling

of the 22-kilometre CityLink system, any section of which can be enlarged in detail with the click of a mouse. Information on traffic or any system of equipment can be overlaid on the map. The display can be segmented into a series of windows showing several different pieces of information at once. The system even allows all the equipment to be tested regularly from the control room, thus reducing the likelihood of a problem during an emergency.

That is only the beginning of what the CCCS can do. It is programmed to automatically detect anything unusual and report it: a fire or high levels of pollutants in the tunnels, an unusual build-up of traffic or a vehicle breakdown, or an interruption to the power supply. For many routine occurrences, the response is also automatic. If a car breaks down, an operator will be alerted and closed circuit television cameras will zoom in on the incident and display it on screen. Or if pollution in the tunnels is building up to a point where it may exceed the allowable limits, the CCCS will coordinate the operation of the ventilation system.

Now comes the smart part. To cope with the less common, less predictable or trivial emergencies, the system is able to call upon a series of pre-programmed logs and files, and provide the operator with options for response. These incident response plans have been developed in consultation with the Emergency Services. They prompt the operator with recommendations as to what steps can or should be taken. If the operator decides that one of these options is appropriate, he or she can set it in motion with the press of a button. But the operator can also override the system and initiate his or her own response. The system will note this new response, review it, and potentially add it to the system’s store of responses. The important thing about the way the CCCS works is that the operator is not swamped with tasks to perform, and is left to make the important decisions. This saves both time and energy.

For example, if a driver stops in one of the tunnels and uses one of the motorist emergency telephones to call the Control Room, a closed circuit television image of the area is provided as the call is going through. The operator will then be prompted to set in train a pre-programmed lane closure plan to alert oncoming traffic. This is done automatically, while the operator is dealing with the problem or forwarding the call to a breakdown or emergency service.

All of this is fine, until some vital link in the chain fails. To minimise the possibility of problems due to such a breakdown, all the essential components of the system
are duplicated. So there is always an identical piece of back-up equipment warmed up and ready to take over in an emergency. Even the optic fibre cabling is duplicated. There are literally thousands of kilometres of cabling, all contained under the walkway either side of the road for full dual redundancy.

An eye to the future

Building such a complicated system of interconnected electronics – the tolling gantries, technical shelters, closed circuit television, emergency telephones, controlling computers – involved a level of precision unusual for civil engineering projects. For instance, the tolling gantries had to be matched to the road’s geometry, because mounted on those gantries are cameras that have controlled focal lengths which are very tight. We are talking about very tight tolerances – plus or minus millimetres. Normally civil contractors are not used to working to that degree of accuracy.

The whole system has been constructed with an eye to the future. It includes spare capacity in most of the electronic systems. It would be easy enough, for instance, to use the e-TAGs for other transactions, such as airport parking. And the tolling software allows for great flexibility in allowing discounts, or catering for special groups of users.
Part III

Engineering Dimensions
Chapter 6. The Monash Freeway bridges: rejecting obvious solutions

Terence Lawless was mesmerised. Along with a throng of curious pedestrians, he watched enthralled while the massive 90-tonne concrete arch, which had supported the Church Street Bridge since 1924, was cut, and then manoeuvred delicately by a monstrous mobile crane onto a haulage truck. The crowd had been fascinated by the painstaking operation, and spontaneously broke into rapturous applause once the concrete slab rested snugly on the truck. As the truck drove away, Lawless noticed that a new, identically shaped steel arch was already in place of the old concrete arch. The fury he had felt when he first arrived at the scene had completely given way to amazement.

Running very late for an appointment in the City, he was in a hurry to get into the Monash Freeway from Church Street, only to learn that the freeway was closed to vehicle traffic that day – the first time since it was built over 30 years ago. A long-time resident of Richmond, it was a rare day that he did not drive on the Monash. It was a vital part of his daily routine: going to work on weekdays and to the shops and his recreational activities on weekends. It was a searing hot day in February 1999, and as he approached the bridge, his temper threatened to match the day’s temperature. What really grated on him was that – having prided himself on being completely abreast of the CityLink development – he had missed the notices about the weekend closure of the Freeway. So he left his car in a side lane, phoned to cancel his appointment, and walked towards the bridge to investigate why the freeway was closed.

The Church Street Bridge was one of five bridges over the Monash Freeway that needed to be modified so that it would weave seamlessly into the fabric of the CityLink.

The upgrade of the Monash Freeway involved the widening of the carriageways – and thus alteration of the overbridges – to provide additional lanes and shoulders. It also involved increasing the height clearance from the carriageway to all overbridges to a minimum of 4.9 metres. The headroom was particularly low, about 4.3 m, under two of the bridges: the Church Street and Cremorne Railway Bridges. Many large modern road freighters and transporters could not fit underneath them, and hence had been prevented from using that part of the Monash Freeway. There was already a history of accidents where trucks had become wedged under the bridges. If CityLink was to clear Melbourne’s CBD and suburban streets of the thousands of trucks that used the city as a thoroughfare, a higher clearance between road and bridge was needed.

The other bridges that needed to be modified were the Gibdon Street Bridge, MacRobertson Bridge and Yarra Boulevard Bridge.
The Church Street Bridge is a well-known Melbourne landmark and considerable consultation with Heritage Victoria was undertaken during design development, to ensure that modifications did not alter the appearance of the bridge.

There were two obvious solutions to gaining more headroom: raise the bridges or lower the surface of the road. But in the end, TOJV and its engineering advisers, Hyder Egis, did neither because both the obvious solutions had major drawbacks.

Raising the bridges would mean having to demolish and rebuild them. This was expensive and would have involved major interruptions to road and rail traffic. The Church Street Bridge is a major artery leading across the Yarra River, to the busy café, shopping and fashion centre of Chapel Street. Removal and replacement of the Cremorne Railway Bridge would have caused even greater disruption as it carried six busy passenger and freight rail lines.

Lowering the road surface also presented problems. Already in places, the Monash Freeway is beneath the flood level of the Yarra River. Sometimes in the past, this has led to significant flooding, a problem that would be exacerbated by lowering the pavement further. Such a move would also have involved lengthy closures of the Monash Freeway, as well as risks to the safety of workers.

In the end, TOJV and Hyder Egis applied some lateral thinking to engineering design, and combined with the use of newer, stronger materials, a clever alternative was found. The original heavy beams and supports of the Church Street and Cremorne Railway Bridges were replaced with smaller, thinner substitutes that were set slightly higher. This created the necessary headroom while maintaining the form and structure of the original bridges. For all but those conducting a most detailed inspection, the bridges look the same.
The Yarra Boulevard and Gibdon Street Bridges were converted from supported structures into elegant cable stayed (suspension) bridges. This strategy of transforming the bridges, as opposed to demolishing and replacing them, was suggested by Hyder Egis. It was one of the first times it had been done in the world. The strategy avoided lengthy closures of the Monash Freeway, and disruptions to traffic on the bridges themselves. Only MacRobertson Bridge had to be closed for any length of time – only a month – while an extra span was inserted.

Indeed, traffic management was one of the critical matters that the contractors had to take into account when planning the various construction activities. It was a paramount consideration in minimising disruption especially during peak periods.

**Church Street Bridge**

The Church Street Bridge across the Yarra River was opened in 1924. It runs north-south and connects Church Street in Richmond with Chapel Street in South Yarra. It also incorporates a tram line. The bridge was formed from three arched spans – two over the Yarra River and the other over the Monash Freeway– strung between four piers. To satisfy the project brief, 0.6 m of headroom needed to be gained under the span above the roadway. TOJV and Hyder Egis also kept to the project brief specification to alter the bridge’s appearance as little as possible. The bridge was listed on the Victorian Heritage Register after the modification.

In the original bridge, the road deck was supported not on a single arch, but by a row of seven matching concrete arches, the ends of which butted into a sloping shelf on the piers. The required extra headroom was created by replacing the concrete arches over the roadway with six lighter, thinner steel arches of similar profile set 70 cm higher. The steel arches were slotted into the spaces between the existing concrete arches. Along the bridge sides, at each end of the row of arches, a fascia that matched the arches of the original bridge was set in place, making it difficult to see that the structure had been modified.

One of the difficulties at Church Street Bridge was that, very little technical information about the original structure, particularly the foundations, had been recorded. This meant that the engineering team could never be absolutely certain of the load-bearing tolerances of all parts of the original structure. So, to avoid any difficulties, the team tried to ensure that the loads on the structure were kept as constant as possible throughout construction. “We actually filled the steel arches with lightweight concrete so the replacement arches weigh exactly the same as the original arches, and the structure itself is not changed in any way in terms of its load,” said Malcolm Short from Transfield, the senior design manager for the CityLink project.
The actual changeover of arches occurred over two weekends in February 1999, when the Monash Freeway was closed for 33 hours, from midnight Friday to nine in the morning of Sunday. The steel arches were lifted up in halves and connected into position beforehand while the existing arches were still in place. This was the first time the Freeway had been closed during the day since its construction in the early 1960s. But even during the closures, the Freeway overbridges remained open to vehicle and tram traffic during the day.

Over the weekend, the load of the bridge was transferred onto the new arches. The old concrete arches were then cut, then lowered onto the pavement. Half the bridge was done each weekend, using four mobile cranes with lifting capacity of up to 225 tonnes, to manoeuvre the 90-tonne concrete arches. The whole operation was carefully monitored by an array of instruments to detect the slightest movement of the bridge structure.

Cremorne Railway Bridge

The Cremorne Railway Bridge was built in 1948. It is a utilitarian structure of thick steel girders supported on concrete piers across five spans. The bridge carries six separate rail lines, and the spans are effectively individual parallel bridges. The northernmost span crosses the Monash Freeway, and was built with a height clearance of 4.3 m. The strategy for increasing this headroom was much simpler than for the Church Street Bridge. New, stronger forms of steel made it possible to replace the original girders with substitutes about half as thick. The rail tracks were fixed directly onto the beams, which created a little more room. In the end the clearance was increased from 4.3 m to 5.3 m.

After the beams were delivered to the site of the bridge, the concrete slabs were poured on top, and the rails affixed to them. Everything had to be carefully measured as the tolerances involved in pinning the new spans into place were tight. Once assembled, the bridge span for each track weighed more than 100 tonnes without ballast. So the erection of the new spans and the removal of the old ones was a major operation. It occurred over the two weekends in February 1999 when the Monash Freeway was also closed for work on the Church Street Bridge. Each weekend, three railway-track bridge spans were removed, and three new spans, together with pre-cast concrete pedestals and one pedestrian bridge, were erected. The operation involved hiring more than $500,000 worth of crane and heavy haulage equipment, including a 300-tonne capacity crawler crane.

It was not only the Freeway that had to be closed. The affected three rail tracks had to be closed, while a fourth track was occupied by a freight train used for the removal and replacement of ballast to anchor the tracks. This train was hauled by diesel, rather than by an electric locomotive, so that the overhead power lines of all four tracks could be switched off to ensure safe working conditions. Closure of the four lines left one ‘up’ and one ‘down’ track operating throughout the weekend. Even so, only a few services had to be replaced by buses.
Just before 5:15 A.M. on Sunday, 15 August 1999, a large number of cars parked in little lanes and side streets of Port Melbourne, the Docklands and North Melbourne, started driving in unison towards the approaches to the Bolte Bridge, a new crossing over the Yarra River. The drivers, determined to take their place in Melbourne’s highway history, were anticipating that at 5:20, the barriers to the Bolte Bridge would be removed to let traffic flow for the first time on the CityLink.

Although it was a Sunday and traffic was expected to be free-flowing, the bridge was choked with vehicles by late morning. And many would remember the opening of the CityLink as being marked by traffic banked up to a kilometre from the bridge, and vehicles slowing down to 20 kilometres per hour.

Sam Marrocco was one of those caught in the jam. He was also one of the early risers who made sure he was ready to cross the bridge when it opened at dawn. Sam was not irate with the slow traffic. “Most of the other people there wouldn’t have minded the traffic. CityLink was toll free that day, and most would have been happy with the thought that it would be free for five whole months. We were all enjoying a Sunday outing.”

Indeed, almost everyone slowed down on the Bolte Bridge to take in the view of the city from a new perspective – the centrepoint which is 34.5 m. above the Yarra River.

Around 4,000 vehicles an hour crossed the bridge that day.

The Bolte Bridge is a key element of CityLink’s western section, the Western Link. It connects the 4.9 km elevated freeway – another Western Link feature which gracefully snakes around the city’s edge – to the West Gate Freeway. Driving on the Bolte Bridge and the elevated freeway today, it is difficult not to feel the spirit of CityLink – the spirit of an open road.

Spanning the river

The Bolte Bridge, named after Victoria’s longest serving Premier, Sir Henry Bolte, became an instant icon among Melbourne motorists. The 140-metre concrete towers straddling the roadway at the central pier became known as the ‘goal posts’. In a city as passionate about Australian Rules Football as Melbourne, the towers provide drivers with the satisfying experience of ‘scoring a goal’ each time they cross the bridge.

The bridge, designed and constructed by Baulderstone Hornibrook Engineering, is a balanced cantilever structure composed of twin, four-span box girders. It crosses the Yarra River and the harbour entrance to Victoria Dock, and has two central spans of 173 m each, and secondary outer spans of 72 m. The 140 m hollow twin towers provide a distinctive focal point to the structure, and can be seen from tens of kilometres away. The webs of the box girders have also been strongly influenced by architectural requirements, with
distinctive wedges developing from the piers, and a ‘step’ to a mid-span platform.

Transurban originally proposed twin reinforced concrete box girder structures with two 176 m-long central spans, and 75 m-long approach spans. The trapezoid-shaped structure would rise 34.5 m above the water level at its centre point. The central pier was to have been set in an artificial island created in the middle of the river by a land extension of North Wharf. The island was to have been built by enclosing an area of the river bottom with a palisade of sheet piles sunk deep into the mud. After the sheets were bolted together, the area they surrounded would have been filled with earth or sand.

To achieve the vision of the towers rising out of the water, Baulderstone Hornibrook and its design consultants, Hyder/CMP, modified the design of the central pier island to avoid the use of the sheet pile-wall. This was achieved by dumping 180,000 tonnes of quarry material from 500-tonne bottom dumping barges. It took 20 days of round-the-clock work to build the artificial island from the riverbed, 13 m down to a metre or two above the surface. Near the top, the screenings were coarser, until finally the whole island was ‘armoured’ with a coating of rocks. The palisade of sheet piles proved unnecessary.

The purpose of the island was not only to stabilise the central pier down to the riverbed, but also to protect it from earth movement, or from collision with a straying cargo vessel.

The central pier and the adjacent 140 m-high concrete towers are supported on 104 large diameter (1.2 m) driven piles, fashioned out of two-centimetre thick steel plate. The piles penetrate up to a maximum depth of 55 m. They were driven open-ended into the mud using the largest pile-driver in Australia, custom built in Finland by Junttan. Once anchored 50 m into the riverbed silt, the top 15 m of silt core was extracted and replaced with reinforced concrete. About 650 tonnes of reinforcement was required in the central pier pile cap, with the 2,700 cubic metres of concrete placed in one continuous pour which took 32 hours to complete.

For the central pier, 56 piles were driven into place, whereas only 18 piles were needed for the piers on each riverbank. Baulderstone Hornibrook and its geotechnical consultant, Douglas Partners, considered that such piles needed only to be driven to the top of the bedrock layer – not set into it – to acquire sufficient resistance to movement to keep the piers in place. The somewhat complicated pier caps were also redesigned and simplified to ensure a much more direct distribution of the load of the bridge through the piers.

Once the piers were in place, the spans were constructed by the balanced cantilever method. All the concrete segments (box girders) were cast in place, progressively
extending out from the piers first on one side, then the other. As the spans between adjacent piers extended further out towards where they would meet in the middle, smaller segments were cast to ease the load of the imbalance.

The segments were then connected together like a necklace, using steel tendons. The tendons were threaded through ducts, which were cast into the reinforced concrete segments. First, each segment was attached to the immediately adjacent segment, but in the final structure some of the tendons ran back the full length from each segment to the nearest pier. The tendons were stressed, or post tensioned, using 700-tonne jacks.

The setbacks

In November 1998, during the final stressing of the tendons on one of the main spans of the southbound structure, engineers encountered a setback in constructing the bridge. (Under the construction program, the southbound structure was built ahead of the northbound structure.) During stressing, the concrete in the vicinity of the jacks – near the ‘step’ in the floor – failed under the load, resulting in localised damage. In effect, the tendons tried to pull out of the floor where they angled upwards into the anchor block.

After investigating, the engineers decided to demolish a floor section of around 8m x 3.5m, and to reconstruct it with strengthened anchor blocks. A new diaphragm wall was also installed at the failed site to provide additional resistance to the upwards force. The tendons were then successfully re-stressed.

This experience resulted in a number of design changes to the northbound structure. Changes included the repositioning of diaphragm walls, reduction in the stressing loads, and careful attention to the positioning of the tension ducts. As a result, the northern structure was completed without incident.

The other main span of the southbound structure had proceeded too far to effect significant changes, although an extra diaphragm wall was added to guard against a recurrence of the problem. Final stressing of this span was completed in March 1999 with no apparent problem. However, shortly after, concrete started to chip off the underside of the structure, at a similar location as the first span. This resulted in the shearing of the concrete across a plane of dense reinforcement, as the tendons tried to pull downwards as they curved over the ‘step’. (The extra diaphragm wall had prevented the upwards pull at the anchor.)

The repair of the second problem was far more complex, as most of the anchors had been completed, and the surplus lengths of tendon had been cut off. The ducts housing the tendons had also been grouted. It was therefore not possible to relieve the stress by releasing the anchors, before rebuilding the floor. Extensive, heavy internal bracing was installed, and the failed area – approximately 8m x 4m – was reinstated with special micro concrete. External plates were also bolted through the floor.

After the second problem occurred, external strengthening was applied to the other ‘steps’ in the southbound structure as a precautionary measure. This was done with steel plates clamped with bolts through the floor.

Both problems were related to the high stresses generated in the vicinity of the architectural ‘step’. Detailed inspections just after bridge completion – and
long afterwards – have shown no signs of distress at the sites of the repairs. Indeed, by the time of the Open Day on Bolte Bridge, the problems had been fully laid to rest.

Around 100,000 people turned up at the Open Day on the morning of 30 May 1999 to experience the bridge on foot – three months before it was to be opened to vehicular traffic. It was a clear, crisp autumn day, and as one of those in the crowd said: “It’s as if a full-capacity crowd at the Melbourne Cricket Ground had poured onto the bridge.”

The elevated roadway

For 4.2 kilometres from the city end of the Tullamarine Freeway, two carriageways snake their way around the western edge of the city: over a railway line and the lower reaches of the Moonee Ponds Creek, over rail yards, docks and major roadways, then across mudflats beside the Yarra River. Leading onto and off these elevated roads is a further 3.5 kilometres of ramps.

The whole road complex was constructed from about 3,500 matched concrete segments carefully slotted together and pulled tight using high-tensile steel tendons. Each segment weighed between 45 and 80 tonnes, and each was uniquely cast.

But it was nearly not done that way at all. Transurban’s original proposal was for a more conventional construction using thin prismatic piers – 30 m apart – spanned by reinforced concrete beams. In early 1996, however, having had another look at what needed to be done, TOJV designers became convinced that segmental construction was a more efficient and flexible way to go.

“I had recently been involved with a large segmental project in Thailand and saw how the technique could be adapted appropriately to CityLink,” said Malcolm Short of Transfield, the senior design manager for the project. “We then discussed our thinking with Baulderstone Hornibrook, our contractor for the Western Link.”

So Baulderstone Hornibrook sent some of its engineers to Bangkok to have a look. As it happened, the major contractor on the Thailand job was Bilfinger+Berger, the German-based parent company of Baulderstone Hornibrook. The touring party came back convinced that segmental match-cast construction would allow faster progress, particularly over the railway line. It was a big decision, as few engineers in Australia had any recent experience with segmental match-cast construction. The only other time the technique had been used in Australia was by Citra Constructions, in building the West Gate Freeway through South Melbourne in the mid-1980s.
The concrete casting facility had enough storage for 800 gigantic concrete segments.

A purpose built straddle carrier could transport a segment over a stack of another two.

“First we had to find a site big enough to build a custom-designed concrete casting facility, and enough storage for 800 gigantic segments. This meant about five hectares of land,” said Pat Cashin, the construction manager for the elevated freeway. “But it also had to be reasonably close to the job site and have good access so we could use large trucks to transport the 80-tonne segments to the erection trusses.”

They found their land in Laverton, where they constructed the largest pre-cast concrete yard in Australia, and the Southern Hemisphere at the time.

The segments they cast were of two types: three lanes wide for the main carriageway, and two lanes wide for the ramps. They all had the same basic shape: an open trapezoidal box with an overlapping flat platform on top, forming wings on either side. It was a bit like a stylised, simplified vertebra.

To form the roadway, the segments were strung together using steel tendons in much the same way as a human spine. Each segment carried about 3.6 m of roadway surface. The three-lane segments were about 16 m wide and the two-lane ones, about 10.5 m wide. But all 3,500
segments were different. Some were straight, some curved, some banked, some flat, but like the pieces of a jigsaw, they were built to fit together.

To ensure they fitted properly, the segments were matched. While each segment was cast, its immediate predecessor was held in place abutting it, as part of the mould. Each unique segment had to be carefully labelled and stored in sequence. A huge purpose-built straddle carrier capable of transporting a segment over a stack of another two was used for the job.

When ready to be used, each segment was lifted onto a 100-tonne capacity low loader and transported up the Princes Highway, around the Western Ring Road and down the Tullamarine Freeway to where it was stored lengthways along the deck of the section of elevated carriageway which had already been constructed.

On the elevated roadway, the segments were loaded, unloaded, manoeuvred and transported by smaller versions of the low loaders and straddle carriers used at the pre-cast facility.

Each span of the elevated road typically was about 45 m, and consisted of about 13 segments. The spans were put together on a pair of trusses about 100 m long, capable of bridging two spans. The pair sat one either side of the central columns of the T-shaped piers used to support the spans. In position, the trusses were like a pair of 100-metre long rails running just above the level of the pier caps. Their 90-tonne weight was carried on huge demountable brackets jutting out from the central column of the piers. The brackets themselves supported large jacks capable of raising and lowering them – and hence the trusses.

At the end of the deck of the roadway which had already been built, stood a large crane known as the segment loader. Anchored to the roadway above the last connected pier, it was a gantry which extended out over the span to be built. A transporter with a segment to be put in place was driven through the legs of the segment loader. The loader then picked up the segment, rotated it 90 degrees, lifted it over the truck and dropped it down onto the trusses. The segment sat so that its wings were supported on two trolley jacks which could move along the rails formed by the top of trusses.

And that was just what happened. Each segment was moved into place along the trusses. The first loaded segment of each span was moved to the far end so that it sat above the next pier. Each subsequent segment was moved along to fit in with the one before, until the thirteenth segment completed the span at the foot of the segment loader. Then, still supported by the trusses, the segments forming the span were strung together with 10 tendons, each comprising 31 strands of 15.2 mm high-tensile steel.

The tendons were threaded through ducts of high-density polyethylene, which fitted through holes cast into the concrete segments. At each end of the span the tendons connected into a steel plate attached just under the deck to the outer side of the first and last segments. The ducts and tendons run through the span in a great bow. From the first segment, in the space of the next three segments, the tendons pass down inside the box to its base. They then run along the base to the fourth
The Western Link elevated freeway faced many difficulties, including busy roads, extensive railway tracks, transmission lines and mudflats.

The system became very efficient and the elevated roadway was rolled out at the rate of one span a day, utilising three erection gantries.

One of the most significant difficulties in constructing the elevated roadway was the ground on which it was built – almost all river bank and mudflat. The basic material, Melbourne’s Coode Island silt, is renowned for being corrosive and for possessing little, if any, structural integrity. Past building works in the area had suffered from misjudgment of the properties of Coode Island silt. The approaches to the West Gate Bridge, for instance, had sunk by more than one metre since their construction, and hence had been the subject of nearly constant, and expensive, maintenance.

On the Yarra mudflats, the approach ramps to the elevated roadway were founded not on dirt, but on lightweight fill composed of polystyrene blocks covered by a waterproof plastic membrane. This kept the load on the mud to an absolute minimum. And along the elevated roadway, the piers were supported by concrete piles driven through mud to an average depth of about 25 m. The total length of the 4,333 piles that were cast and driven is 108 kilometres.

last segment and then up again to the attachment just below the deck.

Once connected, the tendons were stressed or post-tensioned using 700-tonne jacks. Each mirror-image pair of tendons on either side of the span was tensioned at the same time.

Pat Cashin, construction manager for the elevated freeway, said: “This is a very critical – and very delicate – part of the process because the segments are still supported by the trusses and the span, now comprising up to 13 segments, weighs about 900 tonnes. When you start stressing, the span starts to hog – it pulls down at the ends and lifts up in the centre. This transfers the load of the span onto specific points on the trusses; care has to be taken to ensure overloading does not damage the trusses. So, as you gradually stress the span, you must also release the trusses and transfer the weight of the span into its permanent position on the piers. The trusses are released by lowering the truss support jacks seated on the pier brackets.”

Putting together the ramps was a little different because of the constrained area in which the ramps had to be constructed. The trusses sat above the segments as they were strung together. In other words, the segments were manoeuvred into place suspended from the trusses, rather than being supported from below.
CityLink has not only eased traffic in the Melbourne CBD. It has also provided the city with architectural landmarks which create a strong sense of arrival and orientation in Melbourne.

Few things have polarised Melburnians as much as the Gateway. Even as the individual features were slowly appearing on the landscape, residents were divided between those who loved it and those who hated it. The giant yellow beam leaning perilously over the freeway was immediately called the Cheese Stick – either endearingly or sarcastically, depending on where people stood on the divide. Today, however, the Gateway has grown on the city, even among those who disliked it initially, and the splash of red, yellow and orange has been embedded in the subconscious as distinctly Melbourne.

The Gateway concept, developed by the architects Denton Corker Marshall, evokes the feeling of an entrance into the city. Located at the city end of the Tullamarine Freeway, the Gateway comprises:

- a yellow-orange curved concrete sound wall sitting adjacent to the roadway for a distance of 500 m,
- a total of 39 inclined red steel columns or ‘sticks’ arranged in a line on either side of the main carriageway,
- green cladding to a footbridge in front of the Upfield Railway Line Bridge, and
- a 300-metre long skeletal galvanised steel ‘sound tube’ enveloping both main elevated carriageways, designed to reduce noise to adjacent government housing blocks.

The ensemble of Gateway elements was designed to be experienced at 100 kph, and no one has better expressed this experience than an eminent architect and urban planner, Mr Anthony Styant-Browne. Writing in the magazine Architecture Australia, Styant-Browne said:

‘From the north, at the Brunswick Road exit, the freeway curves to reveal the city skyline seconds before the red sticks hove into view, enfilade, connected at the top to the yellow beam forming, for an instant, a portal. Seconds later, the thin red line breaks into its constituent pieces, the beam separates (becoming a boom), and the orange slash of wall appears. In the thick of the threshold, the apparently single line of sticks becomes two, with the latter’s feet set in an elliptical pool – a retarding basin made into art. The entry is pure cinema. At night, the white-lit sound tube hovers above Flemington Road like a flying saucer in a B grade 1950s sci-fi movie.’
Chapter 8. The tunnels:
watershed test for Australian engineers

It was a balmy night, and the group gathered in the dark corner by the frayed ochre couch. The workers were visibly tired and were reviewing their activities of the day, repairing cracks halfway through the tunnel which were discovered four days before.

The men were contemplating the difficult history of the Burnley Tunnel, so far the world’s longest three-lane tunnel, and the structure of which had arguably proved to be the most technically difficult component of CityLink. The opening of the Burnley Tunnel had been delayed by a year because of the vexatious water leakage which had pitched engineers against each other, and contractors against designers. Transurban had presented the tunnel builder, TOJV, with claims for repair and lost revenue due to the delay in operations, and to the closure caused by the discovery of the cracks. In turn, TOJV had taken legal action against the tunnel designer.

When the latest cracks were found, the Melbourne media could only wonder when the saga would end. They posed questions and discussed scenarios. How would this technical issue be resolved and who would take the responsibility? The cost implications were horrendous and a protracted legal battle was possible. If the parties headed for the court, the tunnel might be left unfinished, thus undermining the overall viability of CityLink, and

If walls had ears, then the walls of the public bar of the Rising Sun Hotel in Swan Street, Richmond, would have been privy to the dramatic twists and turns in the construction of the CityLink tunnels, and to the personal, professional and emotional highs and lows of the engineers and construction workers who built them.

It was at the Rising Sun that a lot of the construction workers on the CityLink tunnels relaxed after their shifts, swapping experiences and, in the process, striking friendships that for some will last a lifetime.

On the evening of Friday, February 23 in 2001, just two months after the opening of the Burnley Tunnel, a small group of construction workers were back at the pub.
possibly resulting in catastrophic financial losses to the companies.

But, in the end, public duty took precedence over corporate pride and profitability. Transurban and TOJV recognised it was in their mutual interest to suspend the fight over responsibilities and search for a final solution to the wall failure.

Nine months later, John Laurie did not attempt to disguise his pleasure when he received the news that Transurban and TOJV had settled the damages claim out-of-court. It was the best news he had heard in a very long time, and he thought it would provide an apt closure to his chairmanship of the MCLA, and to the MCLA’s existence as a statutory authority.

It was around midday on the 27th of November in 2001 when the news came through. Transurban had agreed to a final settlement with TOJV. In announcing the settlement, Laurence Cox, Chairman of Transurban, said that had the claims gone to court, it could have taken five years to settle. In addition to a cash settlement of $153.6 million, TOJV also volunteered to install engineering enhancements to provide an additional safety factor against potential water-pressure problems.

Having read the details of the settlement, Laurie was satisfied that it, and the proposed enhancements, would resolve the last remaining substantial issue in the delivery of CityLink. He could now concentrate on the transformation of the MCLA into a special unit of the Department of Infrastructure at the beginning of 2002. He was happy to contemplate the end of his term, and comfortable in the thought that such a unit would provide the continuity and security in the relationship between the Government and the private builder, until CityLink is transferred to public ownership in January 2034.

No matter what views are drawn by future authors and analysts from the problems of the Burnley Tunnel, two conclusions are apparent today: First, the parties made a courageous decision not to be distracted by the threats of litigation, and focused on the engineering solutions in order to deliver a project which has since relieved Melburnians of the atrocious traffic jams they’ve had to bear for decades.

Second, the unique risk allocation between the State Government and the private sector had worked to the overwhelming advantage of the taxpayers. At no time was there any impact on the public purse when problems arose during the construction of CityLink.

Tunnels: the only way across the river

Tunnels were the only realistic and acceptable way in which the east-west traffic could skirt the Melbourne CBD. The most logical way had too many obstacles, including Melbourne’s beloved King’s Domain, the Royal Botanic Gardens and the major sporting precinct.

Indeed, it was the prospect of building tunnels that had interested Transfield in the project. The company had recently finished the successful construction of the Sydney Harbour Tunnel and was looking at other projects where it could put its newfound expertise to profitable use. On the CityLink project, Transfield partnered with Obayashi Corporation, an experienced tunnel construction company with more than 300 tunnels in Japan under its belt.
More than 30 elm trees along the Yarra River bank were removed for the construction of the Domain Tunnel. They were transplanted in temporary locations and replanted successfully after construction.

"To Obayashi, CityLink represented a fairly straightforward tunneling job, but in very difficult conditions," said Hiro Hazama, deputy project director for the Transfield-Obayashi Joint Venture. "Obayashi could provide tunneling technology and expertise to the project. And we had lots of data on tunneling in our databases which could be used to categorise rock and water conditions, and estimate what things would be like."

When the Transfield and Obayashi partnership — which they named Transurban — became the preferred tenderer, it had proposed one short tunnel and one long tunnel. The short (1.6 km) tunnel for westbound traffic became known as the Domain Tunnel, and the long one for eastbound traffic became known as the Burnley Tunnel.

**Minimum requirements**

To efficiently carry the expected volume of traffic of more than 120,000 vehicles a day, those tunnels needed to be at least three lanes wide.

"Three-lane tunnels are unusual," said Malcolm Short from Transfield, the senior design manager for the project. "Generally road tunnels span only two lanes, which means that the CityLink tunnels are wider than most others elsewhere in the world. There was an increased risk in constructing such tunnels."

Determining the cross-sectional shape of the three-lane tunnels was a complex process, governed by several competing factors. First, there were minimum dimensions to be accommodated. The tunnel had to contain three lanes of traffic, each 3.5 m wide, together with 0.5 m of shoulder on each side and a 0.8 m walkway along the right side. The clearance above this roadway had to be at least 4.9 m. So the cross-section had to contain a box of at least 5 m by 12.5 m.

In addition, at the top of the tunnel, there needed to be room for the fans of the ventilation system, and a large smoke duct in case of fire. The top and sides had to house wiring, piping, security cameras, signs, signals and other services. For maximum strength and lack of obstruction by columns, a self-supporting arch-structure was preferable. And clearly, for minimum cost of construction, the tunnel had to be shaped so the least amount of earth needed to be excavated.

For the driven tunnel, the optimum tunnel shape to satisfy all of these competing interests was modeled on a computer. It turned out to be a modified ellipsoid with
curved side walls. Not only did this shape accommodate the traffic envelope and service facilities, it was also strong and an efficient design for excavation by the roadheaders. The shape also provides easy access for steel tunnel supports to be erected, where necessary.

The following sections describe the construction of driven and cut-and-cover tunnels.

**DRIVEN TUNNELS**

Because the whole project needed to be completed in about three years, five road-headers had to be used, each of which excavated about 700 m through the Melbourne mudstone. And given the size of the tunnel and the rock strengths, the largest road-header commercially available – the 350 kW Mitsui S300 from Japan – was employed.

A road-header is a heavy, tracked machine with a short, sturdy boom extending from the front, at the end of which is a milling head, approximately 1.5 m in diameter. As the head rotates, the boom slowly moves from side to side, thus milling out the rock. The machines are electrically powered and are operated by one man seated behind the boom.

The whole of the 700 m-long driven segment of the (short) Domain Tunnel was completed by one machine. The other four machines worked on the 2.9-kilometre driven section of the (long) Burnley Tunnel. One road-header began working in from each end, and the other two began working outwards from a shaft sunk near the middle of the tunnel (the next section describes the digging of the shaft).

**Ground freezing**

To enable faster construction of the 2.9 km driven section of the Burnley Tunnel, a shaft was sunk at the midway point of the tunnel. The shaft, 65 m deep and 11 m in diameter, has become a permanent fixture, functioning as a vent allowing air to be drawn into the ventilation system when necessary, and as a means of emergency escape.

The shaft also played a critical role during construction itself. It was a critical point for the supply of fresh air, and provided the central access for tunnel workers, materials and equipment. As well, the ground through which the tunnel was excavated was hauled to the surface by a massive crane, up the shaft to trucks ready to transport it away.

Construction of the shaft at the site of the former Army Engineers’ barracks, between Olympic Park and Gosch’s Paddock in Swan Street, was a significant feat of engineering in itself, as the tunnelers had to dig the shaft through ground which was highly unstable. Much of the...
The ground through which the shaft was dug was highly unstable and was frozen before digging. Hollow spears were stuck around the perimeter as far as the bedrock, and filled with freezing brine (white tubes in the background of picture).

The tunnels

The tunnels

The ground through which it was dug was too weak to maintain the shaft's structural integrity. An 18-metre band of what are known as the Moray Street gravels proved a particular problem. “They were exactly that,” said Malcolm Short, “permeable water-bearing gravels. If you dug a hole through them without taking any precautions, you would just have water pouring in forever.”

They ended up solving the problem by creating a circular palisade of 40 hollow spears about 1.5 m outside the perimeter of the shaft. The spears were stuck as far as the bedrock, and into them was pumped freezing brine at -35°C – the same stuff they use for ice-skating rinks. After about six weeks, the ground surrounding the area where the shaft was to be excavated had frozen hard enough to prevent the flow of water. The shaft was then dug using a conventional 20-tonne excavator fitted with a hydraulic rock-breaker hammer to break both rock and frozen ground.

Once the shaft had been excavated down into the bedrock, its walls were lined with reinforced concrete, and the ground allowed to thaw. When the shaft was finished, a small road-header was lowered down to begin tunnel excavation in both directions. Eventually the cavity at the bottom of the shaft was big enough to accommodate one of the large Mitsui road-headers which was lowered in pieces and assembled for operation. After it had moved out of the way, a second large road-header descended.

Excavation proceeds

Once a short length of heading had been hollowed out, the roof was stabilised using rock bolts embedded into stable rock. Where rock conditions were poor, large steel arches were used to further stabilise the rock surface. The rock was then secured by a layer of shotcrete, a form of quick-drying concrete sprayed onto a surface using a compressed air gun.

Once the heading was excavated and stabilised, road headers and large hydraulic excavators equipped with
rock-breaking attachments were used to dig out the lower third, or the ‘bench’. After completion of excavation, a polyvinyl chloride (PVC) membrane was placed along the sides and bottom of the bench, to provide a waterproof barrier. Then the concrete invert, or slab floor, on which the roadway would be formed, was poured.

Finally the surface of the tunnel arch was finished with 450 mm of concrete. The concrete was poured in 12-metre segments using a demountable travelling tunnel arch form, which could be collapsed, moved forward and re-erected for the next segment.

The tunnel construction program was designed and scheduled so that much of the fitting out of the tunnels was undertaken in previously constructed tunnel sections, as the road-headers moved inexorably towards each other for the break-through of the tunnels.

All of the activities were occurring simultaneously at some point in the tunnel, and the logistics of maintaining access for workers and materials was a complex exercise.

**Variations to the driven tunnel technique**

While most of the rock through which the tunnels were driven was stable enough to support the standard construction techniques outlined above, in certain areas the material was much more crumbly, much less stable, and needed more careful support during construction. In these regions, notably under the Domain near St Kilda Road, an elaboration of the standard tunneling technique was used.

To stabilise the canopy during excavation of the upper chamber, TOJV developed an innovative technique based on what is known as the Trevi-tube method. Before excavation began, mini-pipes – 114 mm in diameter and 12 m long made up from 3 m sections – were inserted in a splayed arrangement to hold the rock in place just above the proposed canopy. The location and spacing of these mini-tubes were carefully controlled to match ground conditions.

The mini-tubes had small holes pre-drilled along their length. Once in place, cement grouting was injected into the pipes under pressure. This not only increased the strength of the system, but some of the grouting squeezed out of the pre-drilled holes into the surrounding soil and anchored the pipes in place. As excavation proceeded, the whole canopy was braced as a unit using demountable steel beams, while the next section was stabilised in the same way. The tunnelers always ensured about four metres of overlap between consecutive sets of mini-tubes.
The tunnels

Keeping on the straight and narrow

A computerised guidance system was developed for the road-headers which governed the motors controlling the cutter heads, and ensured that tunneling stayed on line and matched the design profile of the chamber. The idea was to allow excavation to proceed at high speed, thus reducing costs.

Unfortunately the guidance system was not robust enough to cope with the severe vibration of tunneling through hard rock, and became less reliable as time went by. Eventually, the tunnelers reverted to a more conventional laser guidance system. But the experience with the computerised guidance system has provided the manufacturers, Leica of Switzerland, with valuable feedback to enable them to modify their technology for future use in similar rock conditions.

CUT-AND-COVER TUNNELS

Where the tunnels were close to the surface – such as at entry and exit portals – and the soil was not stable enough to hold its shape around the tunnel profile, a cut-and-cover method of tunnel construction was used. The principle is simple: Instead of digging a hole underground, the tunnelers constructed an open trench, the bottom part of which is eventually roofed over with a canopy, and then covered or buried with soil. But there are many ways of doing this, and the engineers used several of them for different purposes.

Clearly, in terms of ease of access alone, cut-and-cover is a less expensive method of construction than driving tunnels underground. At the Olympic Park entrance to the Domain Tunnel, the first section of the tunnel was constructed by using pre-cast reinforced concrete arch segments.

The use of pre-cast arch segments enabled construction of this section to proceed rapidly. After excavation of the trench, which gradually deepened as it approached the Yarra River, concrete footings were installed along the outer edges. The half-arch segments were swung into place by crane and placed on the footing. When the first half-arch was in place, it was temporarily supported by a crane while the opposite half-arch of the adjoining segment was put in place. This half-arch on the opposite side was offset longitudinally by a width of 900mm so as to act as a support for the previously placed segment. Erection of the tunnel segments then proceeded efficiently using a single crane, with alternate segments being propped up by the opposing half-segments. A capping beam was then placed along the longitudinal joint at the top of the arch to secure the segments and ensure a waterproof joint. Backfilling over the arch segments followed while the concrete floor was constructed under the arch.

Top-down variation: Grant Street portal

The conventional cut-and-cover method was not used at the Grant Street portal, in part to accommodate the impact on the adjacent Victorian College of the Arts (VCA). Along Grant Street, the Burnley and Domain tunnels are immediately alongside each other before they separate under Kings Domain and the Yarra River on separate vertical and horizontal alignments. The size of the excavation necessary for cut-and-cover was huge: 35 metres wide and progressively increasing in depth to about 25 metres at St Kilda Road. The work was further complicated by the extremely variable ground conditions including the treacherous Coode Island silt, clay, and water-bearing gravels and sands.

The old brick buildings of the VCA were immediately alongside the tunnel excavation. According to Robert

CUT-AND-COVER TUNNELS

Where the tunnels were close to the surface – such as at entry and exit portals – and the soil was not stable enough to hold its shape around the tunnel profile, a cut-and-cover method of tunnel construction was used. The principle is simple: Instead of digging a hole underground, the tunnelers constructed an open trench, the bottom part of which is eventually roofed over with a canopy, and then covered or buried with soil. But there are many ways of doing this, and the engineers used several of them for different purposes.

Clearly, in terms of ease of access alone, cut-and-cover is a less expensive method of construction than driving tunnels underground. At the Olympic Park entrance to the Domain Tunnel, the first section of the tunnel was constructed by using pre-cast reinforced concrete arch segments.

The use of pre-cast arch segments enabled construction of this section to proceed rapidly. After excavation of the trench, which gradually deepened as it approached the Yarra River, concrete footings were installed along the outer edges. The half-arch segments were swung into place by crane and placed on the footing. When the first half-arch was in place, it was temporarily supported by a crane while the opposite half-arch of the adjoining segment was put in place. This half-arch on the opposite side was offset longitudinally by a width of 900mm so as to act as a support for the previously placed segment. Erection of the tunnel segments then proceeded efficiently using a single crane, with alternate segments being propped up by the opposing half-segments. A capping beam was then placed along the longitudinal joint at the top of the arch to secure the segments and ensure a waterproof joint. Backfilling over the arch segments followed while the concrete floor was constructed under the arch.

Top-down variation: Grant Street portal

The conventional cut-and-cover method was not used at the Grant Street portal, in part to accommodate the impact on the adjacent Victorian College of the Arts (VCA). Along Grant Street, the Burnley and Domain tunnels are immediately alongside each other before they separate under Kings Domain and the Yarra River on separate vertical and horizontal alignments. The size of the excavation necessary for cut-and-cover was huge: 35 metres wide and progressively increasing in depth to about 25 metres at St Kilda Road. The work was further complicated by the extremely variable ground conditions including the treacherous Coode Island silt, clay, and water-bearing gravels and sands.

The old brick buildings of the VCA were immediately alongside the tunnel excavation. According to Robert
Cooper, TOJV project director at the time, TOJV had to use a modified cut-and-cover technique to avoid damage to the VCA buildings, to ensure the continuous operation of the busy St Kilda Road, and to comply with the stringent MCLA condition that there was to be no disturbance to the surface of the gardens in Kings Domain. The top-down technique used along Grant Street involved the installation of columns along the alignment of the outer walls of the tunnels, and along the centre line which would ultimately form the barrier between the two tunnels. This was achieved by drilling holes about 900 mm in diameter to bedrock, and then backfilling the holes with concrete. A concrete beam was then constructed along the top of the columns to form the support for the tunnel roof. The roof was made from reinforced pre-stressed concrete beams which were transported to the site to span the gaps between the columns. Once the spans were in place, Grant Street was reinstated and excavation took place unimpeded beneath the deck. As the excavation proceeded, ground anchors had to be installed through the outer columns to provide lateral resistance against the ground pressure outside of the columns, and to safeguard against any ground movement which could have caused cracking in the VCA buildings.

The top-down variation of the cut-and-cover method also reduced the disruption on St Kilda Road, a major thoroughfare with busy tram lines. In fact tram services were closed on only one weekend. The crossing of St Kilda Road was undertaken in stages. Initially the outer service roads were closed and traffic was diverted to the central roadway. This allowed the construction of the columns and tunnel roof in the same manner as along Grant Street. However, extensive propping was necessary under the surface to support the columns against the 25 metre depth of soil pressure. Once work on the outer service roads was completed, traffic was re-diverted to allow work on the central part of the road.

**Secant piles and coffer dams: Yarra River crossing**

The construction of the cut-and-cover crossing of the Yarra River represented some of the cleverest
The tunnels

Yarra River crossing: A trench was cut in the riverbed, the tunnel built in it, and the riverbed placed back on top.

The tunnel walls under the river prior to the construction of the permanent lining.

As it turned out, different techniques of cut-and-cover construction were used on each side because of variations in the riverbed conditions.

The river crossing work began on the east, the Batman Avenue – Olympic Park side. Here, because of the depth of sediment, a top-down approach was used, similar to Grant Street.

A temporary berm, or bank, was pushed out into the river and steel sheet walls were inserted into the riverbed sediment, one on either side of the tunnel. These sheet pile walls extended above the water level of the river, and allowed the water covering the area between the parallel rows of piles to be pumped out. The tunnel walls were then constructed using overlapping (secant) piles inside the line of the sheet piles. To create the secant pile walls, two parallel rows of reinforced concrete piles were constructed, one on either side of the tunnel, extending from just above the riverbed down to the bedrock beneath. To construct each row, two types of 1.2 m diameter piles were alternated. The primary piles, which were set in place first, were reinforced in such a way as to allow secondary piles to be drilled in between them, overlapping by as much as 20 cm to create a continuous wall.

The berm material was excavated and the concrete roof slab was then cast on the secant piles, spanning the engineering of the whole project. Essentially, a trench had to be cut in the riverbed, the tunnel built in it, and the riverbed placed back on top.

As these works could not proceed easily underwater, the river had to be diverted away from the riverbed worksite during construction. The most efficient way to do this, while ensuring minimum disruption to river flows and traffic, was to work on the crossing in two parts: initially shutting off about two thirds of the river from one bank, and, when completed, switching to the other bank, then closing the other third of the river to complete the process.
space between them. This slab eventually formed the tunnel canopy and the support for the riverbed.

The sheet pile coffer dam was then flooded and removed to enable works to start on the other side of the river. At the same time, the tunnel on the east side was excavated beneath its new roof slab.

On the western side, a much larger sheet pile coffer dam was constructed, extending around the worksite to allow an area of riverbed to be pumped out, a trench dug in it, and construction of the roadway and tunnel to proceed from the bottom up.

**Burnley Tunnel: lifting floor and water seepage**

It is ironic that in identifying the safest route to dig a tunnel, the engineers also bought themselves the biggest problem in constructing the tunnels. The safest path for any underground tunnel is through the toughest rock, which provides stability and protection against underground water. For the Burnley Tunnel this was about 65 m under the ground. But with every metre down, pressure from underground water also rose considerably.

At this depth, ground water pressure is at an unforgiving 600 kilopascals – roughly equivalent to the pressure in truck tyres and three times the air pressure in car tyres.

In comparison, the shorter Domain Tunnel is just below the Yarra River.

The first signs that there would be difficulties were flagged by the bore holes driven at the start of tunnel construction. In the case of the Burnley Tunnel, longitudinal cores drilled prior to excavation told the tunnelers they were going to have difficulty with the water conditions in the rock. But they didn’t foresee the extent of the difficulty.

The first outward sign of a problem appeared around August 1997, when large water inflows proved much higher than expected. At the time, the tunnelers were working to the original design: a drained tunnel in which the ground water was simply being pumped out.

Further design analysis showed that continued large inflows would have unacceptable effects on the surrounding groundwater levels.

In late 1997, TOJV decided to change the design of the central section of the tunnel into a tanked or watertight tunnel. The deepest 2.1 km section was sealed with a 3 mm-thick PVC membrane. But where the tunnel was sealed, hydrostatic pressure was generated so it had to have a much thicker floor slab – nearly 2 m thick.
Assessing the impact of tunneling required a clear understanding of the complex geology and ground conditions. “So you need to go through a process of monitoring what is happening,” Malcolm Short said. “We had more than 100 bore holes that we monitored in a number of different ways to measure water levels. We knew the water-bearing capacities of the bedrock and other layers above the rock. And it all fitted together into a model which gave us a much better understanding of the hydrogeological regime.”

Not only was the movement of groundwater monitored through the boreholes weekly, but the potential for soil settlement was also watched carefully. Seven settlement gauges were set in place, near sensitive structures such as the river bridges and the Melbourne Entertainment Centre. About 1000 points along roads, bridges and buildings were regularly monitored for ground movement. Many of these points were established near where tunnel excavation was taking place. In addition, ground conditions and rock deformation were monitored continuously throughout the tunneling process.

Construction proceeded apace with the sealed tunnel, through the middle of 1998 to the first months of 1999. But as the water table rose and the hydraulic pressure on the tunnel increased, holes in the PVC membrane allowed water to leak into the joins between some of the segments. These were plugged with high-pressure grouting which was pumped into cavities between the tunnel wall and surrounding rock. However, cracking was also detected in several places on the concrete slabs underlying the road surface.

A section of 245 m of floor in the vicinity of the shaft midway through the tunnel – the deepest section – suffered significant movements, up to 250 mm upward tilt. At this stage, TOJV initiated an extensive investigation by an expert group of consultants.

The solution

The solution involved the anchoring of the concrete slabs to the rock below with steel rods. A hole about 12 cm in diameter was drilled through the concrete, and a ribbed steel rod 12 m long was lowered into the bedrock. The hole was then filled with fresh concrete and grouting — to seal the rod hole where it punched the PVC membrane, and to grip the rod’s ribs. In the worst affected areas, the rods were only a metre apart, both longitudinally and transversely.

In the 250-metre central section of the tunnel, 2300 rods were installed, while outside the central area, 3000 were installed, at one-metre intervals either side of the central longitudinal joint between the slabs.

Burnley Tunnel: shifting wall-and-floor joint

The leaks discovered on the morning of February 19, 2001 were from two cracks on the southern wall, about halfway through the tunnel at the deepest section.
This was the same area where the tilting-floor problem had occurred. Investigations showed that in one segment, the friction at the joint between arch and floor was not sufficient to develop the necessary anchorage for that section of the arch. This had caused the bottom of the wall, known as the ‘toe’, to move forward by about 35 mm. This in turn, caused the concrete to crack and rip into the waterproof membrane that sits behind it.

The Burnley Tunnel was shut for seven days during the investigations. As the damage was fairly minor, the tunnel was re-opened – with one lane shut – during repairs, which took four months.

Holes were first drilled in some parts of the arch to relieve water pressure and prevent further movements. Then in a section of the arch around 6 m long, the concrete was replaced, first by saw-cutting it into one-metre panels. Piezometers were also installed in several areas to constantly monitor water pressure.

As part of the final rectifications, TOJV inserted steel rods, or dowels, into wall panels to secure them to the floor. This was done throughout most of the length of the tunnel. In some areas, rock bolts were fixed through the arch into the surrounding rock.

The lessons

The problems encountered in constructing the Burnley Tunnel offer lessons to investors and financiers with regard to future infrastructure projects. John Laurie sums up these lessons: “In BOOT projects before CityLink, including those carried out in New South Wales and Queensland, the focus has been on the traffic risk, which is determined by traffic or expectations on road usage. The construction aspects have become a comfort zone for developers, engineers and financiers, and have been taken almost as a ‘given’. CityLink has demonstrated that the technical and engineering risks can still dominate problems.”

The resolution was due – to a significant extent – to the willingness of engineers to keep the lines of communication open. Ken Reynolds, Transurban’s manager for construction who oversaw the work of the construction contractor, said that while there might have been high-level claims and counterclaims, on the ground, the engineers never ceased to talk to each other to find technical solutions.

“We never let legal disputes affect our work; we had to transcend our differences for the sake of the project. There were arguments but we never lost sight of the big picture,” Reynolds said.

On the side of TOJV, Howard Humffray, project director at the time, said: “We couldn’t let legal threats distract us. Our main concern was to find an engineering solution.”

As to the solutions applied to the problems, they were to the satisfaction of CityLink Independent Reviewer, Max Lay. While he may have breathed heavily down the builders’ and contractors’ necks when they were searching for solutions, he recognised their commitment to a high standard of work.

“On a project of this scale and import, things go wrong not because people want to take short cuts. I didn’t need to exert any pressure – they knew what had to be done. They conducted pressure tests in all the problematic sections, instead of hurrying up with a quick-fix.”

Max Lay is confident CityLink can be maintained safely not only in the period when it is privately owned and operated, but for many more years after it reverts to public ownership.
Part IV

The Future
The popular radio current affairs host, who had been a critic of CityLink, declined to use the Domain Tunnel in the first week of its opening. “I came the way I had always come,” he said. “I used Alexandra Avenue instead, which was eerily quiet once you crossed the Swan Street Bridge. It took me a fraction of the time it used to.”

Thinking aloud he went on to say: “I suppose I have to admit that I should thank CityLink for that. Driving down the Avenue was a totally different experience. On one side, I could see through to the Yarra and the city beyond. On the other side, I looked onto the Domain and Queen Victoria Garden. Before, I’d have trucks on either side of me and a feeling of impending doom.”

This probably sums up the pervasive benefits of CityLink for Melbourne. Nowhere are the benefits more obvious than on the banks of the Yarra River, which has been reborn as a focus of Melbourne life. Where once a continuous wall of cars and heavy trucks snarled along Alexandra Avenue, cutting the picturesque river banks off from the Domain and the Queen Victoria Garden, walkers and cyclists are now ascendant.

Just how CityLink has become part of Melburnians’ psyche was demonstrated in a dramatic fashion when the Burnley Tunnel had to close for repairs two months after it was opened. The debate had shifted from whether or not Melbourne should have CityLink, to who was responsible for depriving the city of the newfound convenience which motorists – and truckies in particular – had quickly embraced.

It is easy to forget the impact of the road system on the quality of a city’s life. ‘Marvellous Melbourne’ was acclaimed around the world in the late 19th Century as representing the hopes and aspirations of the city of the future. Built on the wealth of gold the like of which had never been seen before, Melbourne grew into a gracious and opulent city in only 50 years, by which time the city centre was the place to which all roads led.

But with the advent of the motor car, aircraft and telecommunications, the age of urban sprawl was born, and Melbourne’s centre, like that of many cities, became a logjam in the complex mosaic of the greater metropolis.

CityLink has taken a major step toward making Melbourne a 21st Century City – one that has an accessible centre of commerce and culture, but which doesn’t impede the travel and discourse between the surrounding suburbs, which are equal constituents of Greater Melbourne.

The construction of CityLink was a tonic for Melbourne as it struggled to throw off the deep recession of the early 1990s. Launching the project was a statement of confidence in the future, and reflected the great vision, foresight, and commonality of interest of Victoria’s politicians, business leaders and public servants.

The capital works and private investment were an economic stimulus in a State that had lost its way in the economic restructuring of Australia during the 1980s. This restructuring had radically altered the city’s traditional manufacturing base.
But the major benefits of CityLink will be felt in the years ahead:

- reduced transport costs, with savings for consumers and improved industrial competitiveness, and net economic benefits estimated at $280 million annually;
- reduced noise and pollution as trucks flow freely instead of stopping and starting through city streets;
- commuters liberated from the traffic jams that deprive them of time that could otherwise be spent with friends and family, or at work;
- improved quality of life in the city as people reclaim congested CBD streets, and the development of new parts of the city around the Yarra River and Port Phillip Bay become the themes for the city’s future.

By transforming its second largest city, Australia has also gained experience in new ways of doing business. The role of Government in providing infrastructure has also been redefined. Once, it was the norm in Australia for the taxpayer to foot the bill for all public works, and to routinely bail out private contractors for cost overruns even on straightforward projects. On CityLink, Australia’s second largest ever infrastructure project has been delivered with limited public funding, and severe cost escalations have been managed entirely by the private investors and contractors.

The engineering capabilities, including the information technologies and management that underpin the tolling system, the financial and legal skills to deliver BOOT projects on a world scale, and the regulatory experience within government, have enriched the nation’s knowledge base. Some of the players have moved on, but many of those who worked on the project are helping the growth of Australia’s service exports around the globe.

This learning is all the richer for some of the mistakes that were made. This book has not only told of world-first achievements. It has also told of the heartache that came when nature revealed her hand in a physical environment more difficult than it had first appeared, and of the headache that emerged when technology was made to take a giant leap into the great unknown. In the end, the business risk proved not to be in the unwillingness of motorists to pay tolls. It proved to be in the construction and technology.

We have been reminded that when we push the boundaries of knowledge, we still don’t quite know what we will find.

It is important that both the highs and lows of CityLink are recorded. For example, the statistics on safety standards, compared to other projects of this scale, show major progress by the Australian construction industry. But that does not take away the grief caused by the death of one worker during construction. Words can never capture the distress and devastation experienced by all those who worked on CityLink.

As with any exceptional infrastructure, the smooth functioning and convenience of the system will be increasingly relied upon, and soon be taken for granted. Because in the end, the men and women who worked on the project rose and met every challenge. It is not
possible to recognise all the workers on CityLink individually, but this book recognises that all played a critical part in creating this landmark achievement.

Indeed, in awarding CityLink a special Global Award for Excellence in 1999, the Victoria Division of the Institution of Engineers, Australia commented:

*Once in a generation, a project comes along that in sheer scale, technical complexity and overall ambition sets it apart from the rest. These are projects that change the life of a city or region, setting the scene for a new chapter in our nation’s development. In CityLink, Melbourne has had such a project.*

Having posted such an achievement, the question is, will Melbourne now rest on its laurels, or will it take on board the lessons of the project and strive for more?

The needs are certainly there. Within the city, completion of the Northern Ring Road to link the Eastern and Scoresby Freeways, and ultimately link them to the Tullamarine Freeway in the northwest and the Monash Freeway in the southeast, are an immediate challenge.

Linking the Eastern Freeway to the western leg of CityLink through a new tunnel has also been mooted, although the Northern Ring Road might diminish the need for such a massive undertaking. Many of these projects will need a joint public-private sector approach if they are to be delivered at any time in the near future.

The other wheeled track - rail - is also being studied. The fastest growing export sectors in Australia are in Victoria’s rural areas, where high value processed foods and wines are increasingly replacing traditional broadacre crops and wool. Regional centres that only a decade ago were thought to have no future are now booming.

A new relationship is emerging between Melbourne and these regional centres that promises a rich future for the State and a broad and varied lifestyle choice for its citizens. But to realise such a vision, investment in roads, infrastructure and in the engineering, financial, legal and regulatory skills needed to build them is essential. They will have to be matched by the communication and social understanding that will deliver the political will to act and deliver a sustainable path of economic development, environmental improvement and cultural enrichment.
<table>
<thead>
<tr>
<th>Company Name</th>
<th>CityLink-related Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB Fans</td>
<td></td>
</tr>
<tr>
<td>ABB Industry Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Abigroup Contractors</td>
<td></td>
</tr>
<tr>
<td>Advanced Sawing &amp; Drilling</td>
<td></td>
</tr>
<tr>
<td>AE Smith &amp; Son Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>AH Plant Hire</td>
<td></td>
</tr>
<tr>
<td>Aitkin Cranes</td>
<td></td>
</tr>
<tr>
<td>AKZ Engineering Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>ALH Electrical</td>
<td></td>
</tr>
<tr>
<td>Alsafe Safety Industries</td>
<td></td>
</tr>
<tr>
<td>ALSTOM Automation and Control</td>
<td></td>
</tr>
<tr>
<td>Andy's Earthmovers</td>
<td></td>
</tr>
<tr>
<td>Assetta Construction</td>
<td></td>
</tr>
<tr>
<td>Associated Precast Concrete Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Associated Iron Industries</td>
<td></td>
</tr>
<tr>
<td>Atlas Copco Construction</td>
<td></td>
</tr>
<tr>
<td>Auscore Concrete Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Austral Constructions Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Australasian Cable Supports</td>
<td></td>
</tr>
<tr>
<td>Austress Freyssinet Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Boulderstone Homibrook Engineering</td>
<td></td>
</tr>
<tr>
<td>Barro Group Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Barclay Mowlem Construction Ltd</td>
<td></td>
</tr>
<tr>
<td>Barry Webb &amp; Associates</td>
<td></td>
</tr>
<tr>
<td>Basset Consulting Engineers</td>
<td></td>
</tr>
<tr>
<td>Belsby Constructions Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>BHP Long Products</td>
<td></td>
</tr>
<tr>
<td>Blue Max &amp; Clark Earthmoving</td>
<td></td>
</tr>
<tr>
<td>Boral Asphalt</td>
<td></td>
</tr>
<tr>
<td>Boral Concrete</td>
<td></td>
</tr>
<tr>
<td>Boral Masonary</td>
<td></td>
</tr>
<tr>
<td>BRC Piling Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>BRK Constructions</td>
<td></td>
</tr>
<tr>
<td>Brown &amp; Root Services</td>
<td></td>
</tr>
<tr>
<td>BWS Industries Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Caelli Joint Sealing</td>
<td></td>
</tr>
<tr>
<td>Cantilever</td>
<td></td>
</tr>
<tr>
<td>Central Reinforcing Victoria</td>
<td></td>
</tr>
<tr>
<td>Central Weighing Australia</td>
<td></td>
</tr>
<tr>
<td>CDL Consolidated (Vic) Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Chubb Electronic Security Systems</td>
<td></td>
</tr>
<tr>
<td>Clayton Utz</td>
<td></td>
</tr>
<tr>
<td>Clifton Formwork</td>
<td></td>
</tr>
<tr>
<td>Civil Engineering Surveys</td>
<td></td>
</tr>
<tr>
<td>Civiquip Industries</td>
<td></td>
</tr>
<tr>
<td>Clipfit Glazing Systems Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>CMS Management Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Coalville Surveying Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Combitech Traffic Systems</td>
<td></td>
</tr>
<tr>
<td>Comdrain Constructions</td>
<td></td>
</tr>
<tr>
<td>Computer Sciences Corporation</td>
<td></td>
</tr>
<tr>
<td>Common Plant Hire Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Contract Steel Fixers Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Cook’s Construction Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Corcoran Shepherd Consultants</td>
<td></td>
</tr>
<tr>
<td>Corke Instrument Engineering</td>
<td></td>
</tr>
<tr>
<td>Coulson Constructions (Vic) Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Crema Vic Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Crib Retaining Walls</td>
<td></td>
</tr>
<tr>
<td>CSR Australia</td>
<td></td>
</tr>
<tr>
<td>CSR Humes Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>CSR Emoleum</td>
<td></td>
</tr>
<tr>
<td>CSR Ltd</td>
<td></td>
</tr>
<tr>
<td>CTL Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Cummins Engine Co Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Dalwood Lane Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Dames &amp; Moore Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>DECCO</td>
<td></td>
</tr>
<tr>
<td>Deloitte Touche Tohmatsu</td>
<td></td>
</tr>
<tr>
<td>De Nittis Concrete</td>
<td></td>
</tr>
<tr>
<td>Denton Corker Marshall</td>
<td></td>
</tr>
<tr>
<td>DESA Australia Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Di Fabro Constructions</td>
<td></td>
</tr>
<tr>
<td>Douglas Partners</td>
<td></td>
</tr>
<tr>
<td>Down Group</td>
<td></td>
</tr>
<tr>
<td>Donegal Constructions Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>DRC Consultants Inc</td>
<td></td>
</tr>
<tr>
<td>Dugina Shotcrete Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Eastern Energy Ltd</td>
<td></td>
</tr>
<tr>
<td>Ecodynamics Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Edlaw Australia Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>EcoCraft (Aust) Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Enpro Engineering</td>
<td></td>
</tr>
<tr>
<td>Entire Mechanical Services</td>
<td></td>
</tr>
<tr>
<td>Evolution Design Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>FF Building Services Ltd</td>
<td></td>
</tr>
<tr>
<td>Firmsec International Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Fleet Plant Hire</td>
<td></td>
</tr>
<tr>
<td>Fletcher Construction Australia</td>
<td></td>
</tr>
<tr>
<td>Fitzgerald Construction Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>GEC Alsthom Austral Ltd</td>
<td></td>
</tr>
<tr>
<td>Geelong Civil Constructions Ltd</td>
<td></td>
</tr>
<tr>
<td>Gerristone Excavations</td>
<td></td>
</tr>
<tr>
<td>Gordon Services Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>GFC Industries Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Giant Access</td>
<td></td>
</tr>
<tr>
<td>Global Pacific Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Goldner Associates Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Graffiti Coatings Vic</td>
<td></td>
</tr>
<tr>
<td>Gutteridge Haskins and Davey</td>
<td></td>
</tr>
<tr>
<td>GVP Fabrications</td>
<td></td>
</tr>
<tr>
<td>Haden Engineering</td>
<td></td>
</tr>
<tr>
<td>Henshall Mammolito Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Hercules Engineering</td>
<td></td>
</tr>
<tr>
<td>Highrig Crane Hire</td>
<td></td>
</tr>
<tr>
<td>HLA Envirosciences Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Hollow Core Concrete Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Hooker Cockram Limited</td>
<td></td>
</tr>
<tr>
<td>Huber &amp; Suhner (Australia) Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Hu-Metal Engineering Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Hyder/CMP Joint Venture</td>
<td></td>
</tr>
<tr>
<td>IBM Australia Limited</td>
<td></td>
</tr>
<tr>
<td>Industrial Hydraulic Service</td>
<td></td>
</tr>
<tr>
<td>Integrated Security</td>
<td></td>
</tr>
<tr>
<td>ITT Flygt Limited</td>
<td></td>
</tr>
<tr>
<td>JA Dodd Contractors</td>
<td></td>
</tr>
<tr>
<td>James Crane Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>Jaydo Construction</td>
<td></td>
</tr>
<tr>
<td>JF Madigan Surveying Pty Ltd</td>
<td></td>
</tr>
<tr>
<td>John Holland Construction</td>
<td></td>
</tr>
<tr>
<td>Kallis Constructions</td>
<td></td>
</tr>
<tr>
<td>Kane Constructions (Vic) Pty Ltd</td>
<td></td>
</tr>
</tbody>
</table>
Kay Mainline Pty Ltd
Kelly Steel Fabrication
Kilpatrick Green Victoria
Kingston Plant Hire
Kinhill Engineers Pty Ltd
KV Johnson Constructions Pty Ltd
Lampson (Australia) Pty Ltd
Lifesafe Engineering Pty Ltd
MBT (Australia) Pty Ltd
McConnell Dowell
M&C Concrete Pumping Pty Ltd
Metcalf Construction Services
Metal Acoustic Products
MGP Electrical Pty Ltd
MGT Environmental Consulting Pty Ltd
Middendorp Electric Co Pty Ltd
Minesco Industries
MM Cables
Morson Engineering Pty Ltd
Motherwell Information Systems
Muller Industries Aust Pty Ltd
Natural Stone Construction
National Contracting Group
Nationalpipe Pty Ltd
National Power Services Pty Ltd
NEC Australia Pty Ltd
Nick Baldi Constructing Pty Ltd
Nielson-Wurster Group Inc
Nightlight Markers
Nilsen Electric (Vic) Pty Ltd
Nuttshell Graphics
O’Donnell Griffin
OD Transport (Vic)
Olex Cables – P&I Division
Otter Brown Engineering
Page Steel Fab Pty Ltd
Parkinson Asphaltng Pty Ltd
Pennmas Engineering & Construction
Pioneer Road Services
Pirelli Cables Australia Ltd
Plastral Fidene Pty Ltd
PM Doherty
Plastic Solutions Australia Pty Ltd
Profab Engineering Pty Ltd
Quarry Mining & Construction
Quickweld Engineering Pty Ltd
Quinn Civil Contractors
Rahugh Constructions
Raven Industries Pty Ltd
Rawl Australasia Pty Ltd
Reinforced Earth Pty Ltd
RE & LM Gertzel Pty Ltd
Relex Australia Electrical Supplies
Ribiand Steel (Wangaratta) Pty Ltd
RJ Kirwan Landscaping
Rodek Fencing Pty Ltd
Rodden Constructions Pty Ltd
Rolf Wessell Pty Ltd
Rowe & Thomas Pty Ltd
Rulway Mechanical & Construction
Rutherford Power Pty Ltd
RS & E Engineering
RW & S Elliott Engineering
RW Knight Plumbing Pty Ltd
Rypbrook Pty Ltd
Schneider Pty Ltd
Secvic Civil Engineering Pty Ltd
Sergi Crane Services
Shaft & Tunnel Pty Ltd
Shantell Pty Ltd
Sinclair Knight Merz
The Shell Company of Australia
Sides Engineering Pty Ltd
Siemens Ltd
Simoco Pacific Pty Ltd
Skilled Engineering Services Pty Ltd
Skilled Maritime Services Pty Ltd
Smorgon ARC
South Geelong Engineering Pty Ltd
Sovereign Concrete Products
STA Pty Ltd
Standard Roads
Stockford Accounting Services Pty Ltd
Stockport Civil (Vic)
Streetscapes Pty Ltd
Strongforce
Super Mini Earthmovers
Superior Steelfixing
Sutville Pty Ltd
Swanhaven Pty Ltd
Sweetman Fasteners
Symon Services
Tamrock Coal Australia Pty Ltd
Telstra
Tennant Ltd
Thornton Engineering
Thom Lighting Pty Ltd
Thytec Australia Pty Ltd
TK Steelfixing Pty Ltd
TLS Steelfixing Pty Ltd
Touchdown Holdings Australia Pty Ltd
Transfield Construction
Transfield Fabrication
TransLink Systems Pty Ltd
Trox (UK) Ltd
TQR Pty Ltd
Unicrete Industries Pty Ltd
Veitch Leister
Vibropile (Aust) Pty Ltd
Victorian Plant Hire
Vic Pits
Vic Water Pty Ltd
VicWide Structural Rigging
Vinindex Tubemakers (Aust) Pty Ltd
Vipac Engineers & Scientists Ltd
VSL Prestressing Vic
Wagstaff Piling Pty Ltd
Wells Eden Nominees Pty Ltd
Westcombe Heavy Haulage Pty Ltd
Westkon Precast Concrete Pty Ltd
WH Electrics (Vic) Pty Ltd
Wilby Tower Pty Ltd
Witt & Sohn
Wormall Fire Systems
Wreckair Pty Ltd