1.0 Introduction
The Brisbane Airport Link (APL) is a 6.7 km long urban motorway tunneling project which is being delivered in conjunction with a northern extension of Brisbane’s dedicated busway system and a major upgrade of the approach freeway and entrance to Brisbane Airport. A single contract for all the works will deliver the APL as a public private partnership (PPP), with the balance of the works being procured through a traditional design and construct approach. The combined capital value of the works is $4.2 billion (Australian dollars (AUD = 0.9101 USD)) making this the largest single public infrastructure project undertaken in Australia. The contract for the works was signed on 30 July 2008 and construction is due to be completed in June 2012.

The unidirectional tunnels involve sections of three lane tunnel constructed in hard rock using roadheaders and sections of two lane tunnels in softer ground conditions constructed using two 12.5 metre diameter earth pressure balance TBMs. Entry and exit ramps of various cross sections are also being constructed using roadheaders with a total of fifteen such machines likely to be employed on the project.

This paper is jointly authored by representatives from the PPP concessionaire (BrisConnections Pty Ltd) [1] and the specific agency formed by the State of Queensland, City North Infrastructure (CNI) [2] to deliver this major project. The topics addressed will include an explanation of the innovative process adopted in selecting the constructor, details of the private sector funding arrangements and an overview of the engineering challenges presented by the scale and complexity of the project. The paper will also include a description of the current status of construction and the solutions that have been adopted to date. The technical issues addressed will include tunneling in a wide range of geotechnical conditions, tunneling under sensitive structures and the excavation of large underground spaces.

2.0 Background
South East Queensland (SEQ) is the fastest growing metropolitan region in Australia. By 2026, the population is expected to increase by more than 1 million to 4.5 million people. A key aspect of achieving sustainable growth in SEQ is the development of an accessible, attractive and efficient transport system.

APL is part of the Queensland Government’s regional planning and Brisbane City Council’s local planning. APL is a predominately underground toll road that connects Brisbane’s northern suburbs to the Airport, the newly constructed North South Bypass Tunnel (CLEM 7) and the existing Inner City Bypass (ICB). APL will provide a primary orbital function for traffic to bypass the CBD (via CLEM 7 and the ICB) and a secondary radial function between the Brisbane city frame and the northern suburbs, Brisbane Airport and Australia Trade Coast. The APL and Clem7 projects form part of the TransApex suite of five major road transport projects, primarily tunnels,
designed to form an inner ring road around the CBD and a freeway connection to the airport (see Figure 1).

A dedicated Busway network (current value AUD2.1 billion) is a key strategic initiative to improve public transport in the greater Brisbane area. The Northern Busway (NB) is a two-way bus-only roadway and forms one of the three radial arms that makes up the Busway network. The extension to the NB being delivered in conjunction with the APL is approximately 3.5 km long and consists of two Busway Stations and two signature bus stops (capital value AUD444 million).

Brisbane Airport and the Australia Trade Coast are experiencing considerable traffic growth which is generating significant traffic congestion at the existing Brisbane Airport entrance, the location of the Airport Roundabout. The Airport Roundabout Upgrade (ARU) (capital value AUD272 million) was developed and bid during the interactive tender process. The ARU includes a new flyover bridge connecting the toll road to the Brisbane Airport and upgrading the existing roundabout to a new “fast diamond” intersection.

![Figure 1. Plan of the proposed TransApex suite of road projects including the Airport Link](image)

2.1 Joint Delivery

Planning for APL was undertaken in partnership with the planning for the extension to the NB as the two projects have a shared corridor between Bowen Hills and Kedron. The State of Queensland pursued an integrated planning and public consultation approach to maximize benefits to the State and minimize impacts on the local and wider community.
At the completion of the integrated planning phase of the projects the Queensland Government established a wholly government-owned company, CNI Pty. Ltd. (CNI), to manage the delivery of the APL and the extension to the NB. This included the procurement, evaluation and contract management phases of the projects. During the procurement process ARU was included in the construction works to be delivered.

Efficiencies have already been realized during the planning, procurement, evaluation and approval phases which were run through a single joint delivery process. These benefits are being further evidenced through the construction delivery phase.

2.2 Project Timeline
Planning for the APL and NB projects commenced in 2005 and was released for public display and comment in 2006. Procurement commenced in 2007 with the Request for Proposals sent out to shortlisted consortia in June 2007. The procurement process was expedited through an interactive tender process and the preferred tenderer was announced 11 months later in May 2008.

<table>
<thead>
<tr>
<th>DATE</th>
<th>MILESTONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2006</td>
<td>Airport Link EIS [3] and Busway CDIMP displayed</td>
</tr>
<tr>
<td>February 2007</td>
<td>Expressions of Interest Called</td>
</tr>
<tr>
<td>April 2007</td>
<td>Coordinator-General conditionally approves EIS for Airport Link [4], Transport Minister approves CDIMP</td>
</tr>
<tr>
<td>June 2007</td>
<td>Announce shortlist and invite tenderers</td>
</tr>
<tr>
<td>December 2007</td>
<td>Consortia submit proposals</td>
</tr>
<tr>
<td>May 2008</td>
<td>BrisConnections announced as preferred tenderer</td>
</tr>
<tr>
<td>June 2008</td>
<td>Coordinator-General approves the BrisConnections Changed Project [5], Transport Minister approves amended CDIMP</td>
</tr>
<tr>
<td>June 2008</td>
<td>Commercial/Financial close (contract awarded)</td>
</tr>
<tr>
<td>November 2008</td>
<td>Construction begins</td>
</tr>
<tr>
<td>November 2008</td>
<td>ARU Environmental Assessment Report approved</td>
</tr>
<tr>
<td>March 2009</td>
<td>Roadheader tunneling commences</td>
</tr>
<tr>
<td>June 2009</td>
<td>Wooloowin Modification submitted to Coordinator-General for Approval</td>
</tr>
<tr>
<td>October 2009</td>
<td>Wooloowin Modification approved by Coordinator-General [6]</td>
</tr>
<tr>
<td>December 2009</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; TBM arrives in Australia</td>
</tr>
<tr>
<td>March 2010</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; TBM arrives in Australia</td>
</tr>
<tr>
<td>May 2010</td>
<td>TBM tunnelling commences</td>
</tr>
<tr>
<td>June 2012</td>
<td>Projects due for completion</td>
</tr>
</tbody>
</table>

Table 1. Timeline for delivery of projects

Construction officially commenced in November 2008 and since that date further geotechnical information has been collected which shows that the ground conditions are less conducive to tunnelling than anticipated in Kedron area. BrisConnections and their design and construct contractor, Thiess John Holland, (TJH) have investigated means of addressing these conditions to avoid any delay to the scheduled completion date of July 2012. This has necessitated the construction of an additional access shaft at Wooloowin to create further work faces. As this was not envisaged in the original or changed project planning approval an additional Request for Project Change was submitted to the Coordinator-General for consideration. This measure was
subjected to a process of independent review and public display and was approved in October 2009.

3.0 Innovative Procurement and Selection Process

The projects are being delivered in accordance with the Queensland Government’s Value-for-Money Guidelines. Under this process, a reference project is developed for the purposes of project evaluation and planning approval, and subsequently for comparing private sector delivery model outcomes. These guidelines were used to develop business cases that recommended joint delivery of the projects with APL as a Queensland Government led PPP and the NB as a traditional Design and Construct contract.

The key features of the procurement of the projects are as follows:

- The joint procurement of the APL, NB, and ARU, whilst maintaining the identities and functionality of the three projects
- Combining the procurement of a PPP with two integrated design and construct contracts
- Interactive meetings will all tendering consortia during the interactive tender process
- Project Approval mechanisms that allowed for flexibility and innovation to be captured within the tendering process
- Providing a financial contribution to the consortia for the PPP contract
- Providing a financial contribution to the unsuccessful proponents.

3.1 Interactive Tender Process

The Queensland Government was driven to obtain the best outcomes for the State during the procurement process and carefully investigated how the competing needs of value for money, innovation (both design and construction methods), certainty of delivery and stakeholder outcomes (both government and community) could be balanced.

To obtain the best possible proposals CNI undertook an interactive tender process that provided an active interface with CNI and other government stakeholders. These interactive meetings managed by CNI provided the proponents with the opportunities to seek clarification on design and construction, land tenure, planning and approvals, contracts, and stakeholder requirements.

A key feature of this process was the need for CNI to clearly articulate the thinking, constraints and community feedback that had driven project decisions. This was achieved by providing a detailed reference design that articulated where improvements/changes could be made, electronic data rooms that included all information used during the planning phase, interactive meetings, and formal correspondence. This provided tenderers with an insight into the certainty and outcomes that the State required and allowed them to make value judgements regarding innovations and value for money solutions they wished to propose.

During the interactive process all parties were cognisant of the need for transparent and equitable treatment of all tenderers involved in the procurement process. An independent probity auditor was appointed by the State and was present at all the meetings with all of the tenderers. Furthermore all discussion with all State Government and local Government agencies was facilitated by CNI with the probity auditor in attendance.

3.2 Project Approvals

The role of the Coordinator-General (CG) was established in 1938 and is an independent State representative who coordinates the impact and management of significant projects in Queensland.

The Project follows a traditional approval process with the public display of an EIS and a report that details and addresses the submissions received. The CG takes all submissions into account and prepares a CG’s evaluation report. This CG’s report will include an assessment and
conclusion about the environmental effects of the project and any associated mitigation measures and conditions the proponent must follow before the project can proceed.

The CG approved the EIS for APL in May 2007. In the CG’s report it was intended that through the PPP partnership with the private sector that innovative project solutions would lead to design improvements to the reference design detailed in the EIS. These innovations were recommended by the CG to further mitigate the risk of project impacts in a manner that complied with safety, reasonable cost, and the project objectives.

The statutory approval process for an EIS allows for a proponent to change the project (although not significantly from the original EIS) and provide a change notification to the CG who will complete a CG’s change report as an evaluation of the amended project.

Following the evaluation process BrisConnections was identified as the preferred tenderer. BrisConnections design was generally similar to the EIS reference project although it incorporated a number of significant improvements or innovations which led to changed impacts in terms of scale and location. The Request for Project Change was submitted to the CG and was approved in June 2008.

4.0 Project Funding

The funding arrangements for the overall project are unusual in that The Airport Link project is a Public Private Partnership (PPP), which is predominantly privately funded, whilst the Northern Busway and the Airport Roundabout Upgrade are design and construct works fully funded by the State. Whilst this arrangement may not be unique it is certainly a distinguishing feature of the funding of this project.

The total financing value of all the projects is AUD5.6 billion (finance cost and interest plus a Government Contribution of AUD983 million (APL AUD267 million). The Airport Link funding is recovered by charging a toll to users over the 45 year concession period that BrisConnections have been awarded by the State of Queensland. After that period the ownership of the asset will pass to the State.

The private sector funding consists of both debt and equity elements. The debt finance is provided through a syndicate of international banks and equity finance of AUD1.2 billion which was raised through an Independent Public Offering (IPO) which corresponded with the listing of BrisConnections on the Australian Stock Exchange in July 2009. The equity funds are actually raised through 3 installments of $1 for each unit.

Raising finance for a project of this scale at the time of a ‘global financial crisis’ has proven to be an interesting experience. However, all the required funding is now in place and there are no refinancing obligations until mid 2018, some six years after the opening of the toll road.

The actual value of the design and construct contract awarded by BrisConnections to the D&C Contractor, for all three projects is AUD4.2 billion which is easily the largest single contract ever awarded in Australia for infrastructure works.

5. Project Challenges

The tender process outlined the State’s desires and required project outcomes, provided considered options to the prospective bidders and allowed for the proponents to provide innovative value for money solutions.

BrisConnections’ tender proposal offered substantial improvements to the reference designs that the State had considered for the project. Whilst these solutions both improved many the State’s outcomes they also created new challenges for the projects.
The scale and complexity of the combined Airport Link Scheme presents a number of technical and logistical challenges. Many of these have been addressed in the design process and the earlier phases of the construction stage. However, a number of such challenges, particularly the adaption of the design to the actual geotechnical conditions as they present themselves, remains ahead of the construction team.

5.1 Tunnel Alignment and Revised Methodology

The BrisConnections alternative proposal for the Airport Link Main Line tunnel was the result of a true multi-disciplined approach that considered design, construction, safety, traffic (both construction and permanent) and community outcomes. The design objectives of the main line alignment were driven by the connection demands of the three surface interchanges – at Bowen Hills, Kedron and Toombul, and the desire to adopt a cost-effective and safe solution that would, where possible, engage the best available geological strata.

The tunnel alignment was revised both vertically and horizontally to reduce grades and promote a safer road environment. The alignment selection also considered ground conditions and was adjusted to engage superior geology in order to reduce the risk of ground surface settlement and optimize the primary and secondary tunnel lining arrangements.

The previous proposed construction methodology was reviewed and changed to reduce community impacts recognizing that the construction of such a large and complex infrastructure project in an inner urban environment would result in some level of disturbance to the community. These changes included the addition of a mid tunnel access shaft located at Truro Street to provide additional tunnel work faces, extending the length of tunnel excavation using tunnel boring machines (TBM’s), and revising the launching arrangements for the TBMs to drive westbound from Toombul. This later revision facilitated the provision of a purpose built conveyor which transports the material excavated by the TBM’s some 3 Km to a spoil loading facility remote from the local residential community and adjacent to the arterial road network. This measure reduced the impacts on the local road network by removing approximately 80,000 truck journeys from the local streets.

The relocation of the TBM operations from the original Kedron site to Toombul, at the north east, did resolve a significant interface issue with the local high school and the Emergency Services at Kedron. However the Toombul site is situated in a residential precinct and State Heritage listed park which is prone to flooding and this presents the project with new challenges. Construction of a launching chamber for two 12.5 metre diameter earth pressure balance TBM’s and the associated supply facilities for such an operation in such an environment has created significant community concerns which have to be managed by TJH with support from BrisConnections and CNI. The issues that have been of particular concern to the local residents include the management of noise, dust, air quality, hours of work, plus visual and permanent amenities. Some five Community Liaison Groups have been formed across the projects. These independently facilitated groups meet on a monthly basis in order to better inform the local community of the progress of the works, the upcoming activities and to receive feedback from representatives of the local residents and businesses.

5.2 Underground Kedron Connection

As a consequence of revising the alignment to engage in superior geological conditions, the Kedron Connection, being the midpoint of the APL, was changed from a predominantly surface based arrangement to being, primarily, a network of underground ramps and tunnels. This enables construction traffic management to be significantly improved as a substantial proportion of the cut and cover tunneling indicated in the reference design was replaced with driven tunnels. This arrangement also greatly reduced the extent of surface roads in this precinct, minimized the impact on local schools and provided much smoother vehicular flow through the connection and improved pedestrian connectivity to the Kedron Brook Busway Station.
During the planning, procurement and tender phases a significant amount of geotechnical information was gathered. The revised alignment was situated to take advantage of the Brisbane Tuff that underlies the alluvial soils present throughout Brisbane’s northern suburbs. Further investigation has demonstrated that while the Brisbane Tuff is present the extent and quality of the rock is less, in some specific locations, than had been originally anticipated. This has led to new challenges which have had an impact on the construction method, design and planning for the project. These conditions have resulted in some changes to both the design and construction of the tunnels with some of the proposed traditional hard rock tunneling for the ramps now being undertaken using a slower and more involved NATM approach, the additional tunnel access shaft described earlier in Section 2.2, and re-consideration of how to best construct the large underground caverns at Kedron which are required to accommodate the merge and diverge connections between the respective ‘on’ and ‘off’ ramps which connect with the mainline tunnels. These caverns are relatively wide structures with a maximum span in excess of 25 metres. Additionally these caverns need to be constructed, at least to the point of completing the heading and associated support, in sufficient time for the TBM’s to be able to ‘pass through’ the caverns in early 2011.

Figure 2. Kedron: Construction of east bound on-ramp

5.3 Further Innovations

The mechanical ventilation for the tunnels is designed as a longitudinal system which expels tunnel air from three ventilation stations, one each at Bowen Hills (south), Kedron (mid-point) and Toombul (north east). The presence and scale of these ventilation buildings, which accommodate the axial fans, attenuators and other equipment necessary to address the stringent air quality standards specified, was identified as a concern to the local communities, particularly at Bowen Hills and Toombul. In response to these concerns BrisConnections’ design has fully submerged the station at Toombul and partially submerged the building at Bowen Hills. The subterranean construction of these structures adds considerably to the complexity of both their design and construction.
Whilst not uniquely offered by BrisConnections but rather through the requirements of the performance specification for the projects, the tunnels do contain a number of fire and life safety systems (F&LS) not regularly provided elsewhere in the world, as well as all the other F&LS systems expected in a modern urban motorway tunnel. These unusual features include the provision of a dedicated, ceiling mounted, smoke duct throughout the length of the longitudinally ventilated tunnel and the provision of an overhead deluge system capable of delivering a water discharge of 10mm/m²/min, at an identified fire incident site, at any location within the tunnel.

6.0 Current Status

As indicated earlier the Airport Link Project is due to be completed in June 2012. The Northern Busway Project is required to be opened at least two months earlier in order for BrisConnections to commence tolling of Airport Link. The ARU is scheduled to be complete in early 2012 but this is, in fact, likely to completed substantially earlier than that date.

As of November 2009 after one full year of construction the overall project is actually 30% complete by expenditure and some 5 million man-hours have been worked to date. The safety record on the projects is of a very high standard with a lost time injury frequency rate of less than 1.5 (i.e.<1.5 lost time injuries per 10⁶ hours worked). Completion of such a large project in the relatively short time frame available dictates that the rate of expenditure must be maintained at a high level for the balance of the contract period and monthly payment claims, in excess of AUD150 million, are anticipated during the next twelve to eighteen months of construction.

All the major construction sites for the project are now well established and production is ramping up to the level required to sustain the level of expenditure described above.

One TBM has now arrived in Australia and will commence tunneling in May 2010 and the second machine, which has already been successfully commissioned in Germany, will arrive in March 2010. To date, some 11 roadheader tunneling machines are employed on the projects and a further 4 machines will be engaged in early 2010. This number of machines is necessary given the multiple work faces that are required to meet the aggressive time lines for the projects.

It is also of interest to note that two thirds of the spoil volume generated in the excavation of the 16km of driven tunnel involved in the project will be excavated by roadheaders and one third by TBM’s.

7.0 Conclusions

The three projects that form the Airport Link, Northern Busway and Airport Roundabout Upgrade Projects are each significant projects in their own right. To deliver all three projects simultaneously in the short time frame available represents considerable technical and logistical challenge. However, to date, the project remains on program for delivery, by the due dates.

This paper focuses on planning and approval procedures, some design issues and some early construction experiences. As the project proceeds there will undoubtedly be further construction experience that will merit further technical papers related to the projects.

References