LAWRENCE HARGRAVE DRIVE
SEA CLIFF BRIDGE COALCLIFF, NSW

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ABSTRACT

Lawrence Hargrave Drive had suffered numerous dangerous rock falls and embankment failures over the previous 100 years. In 2003, analysis by the road owner RTA ascertained a slope risk profile existed that was unacceptable, forcing the immediate closure of the road. With a demonstrably unstable slope to work on - the Pacific Ocean on one side and a 300m cliff on the other - the socio-political necessity to re-open the road as quickly as possible demanded innovative solutions.

The first critical decision that established the platform to deliver a successful project was the adoption by the client of the Alliance design and construction delivery method – a first for an RTA road project. Multi-criteria analysis in a series of workshops identified the optimal delivery solution to be a near-shore bridge – combining both in-situ cast Balanced Cantilever and Incremental Launch techniques in a single bridge – with additional geotechnical stabilisation and associated roadworks.

The LHD Link Alliance team comprised Laing O'Rourke (then Barclay Mowlem), Maunsell, Coffey Geosciences and the RTA, operating in an 'open book' alliance with a full Pain/Gainshare arrangement measured by an independent Performance Review Team.

The project was delivered 3 months ahead of schedule, suffered zero LTIs from 285,000 man-hours – much of it working at heights – and featured not less than 135 separate innovations, creating an iconic structure for the people of the Illawarra Region and a pure alliance exemplar for the RTA and the wider construction industry.

KEY WORDS

LHD Alliance, Sea Cliff Bridge, balanced cantilever, incremental launch, bridge, Ground Probe, formwork traveller, Coalcliff Colliery, Lawrence Hargrave Drive.

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COMPLEXITY AND DIFFICULTY OF THE CONSTRUCTION TASK

The project totalled 1350m in length and included significant roadworks and targeted geotechnical slope stabilisation. The main structure is a curved, Balanced Cantilever Bridge (BCB) adjoining a 150m radius curved Incrementally Launched Bridge (ILB).

The construction of safe access roads on acceptable grades on unstable slopes was one of the most significant challenges for the team.

Balanced Cantilever Bridge at a glance

Length	455.6m including 6m approach slab
Depth	variable box depth 6.0m to 2.5m
Spans	5 number (62m, 3 number 108m, 61.2m)
Height	41m at highest point
Down Hill Gradient	constant 2.5%
Total Weight	17,650t
Volume of Concrete	6,700m3
Total Weight of Reinforcing Steel	1,343t
Total Length of Prestressing Strands	162,000m
Pile Cap	4 number 8.5m x 7.5m x 2.5m
Piers	4 number 6m x 2.8m up to 26m high
Pier Construction	7.5 months (non continuous)
Deck Construction	11 months including pier heads

Incrementally Launched Bridge at a glance

Length	209.4m including 6m approach slab
Depth	constant 2.5m
Spans	6 number 30m and 1 number 23m
Height	30m at highest point
Down Hill Gradient	constant 2.5%
Total Weight	9,750t
Volume of Concrete	3,800m3
Total Weight of Reinforcing Steel	487t
Total Length of Prestressing Strands	45,100m
Pile Caps	3 pile caps up to 6.75m x 5.41m x 2m
	4 pad footings 6.4m x 3.2m x 1.3m
Piers	7 number 6m x (1.7m & 2.8m) up to 22m high
Typical ILB segment size	15m long x 13m wide
Deck Construction	6 months

In-situ BCB construction, although fairly common in Europe and North America, is unusual in Australia - the last such bridge constructed for the RTA in the early 1980s, was at Mooney Mooney on the F3 Freeway. No BCB in Australia had ever before been built with a mix of straight sections and sections with variable curvature, and never in conjunction with an ILB as part of a single structure.

Despite the additional constraints of the site, weather and access, the team was able to achieve world record traveller turnaround times of as little as four days.

The 150m radius curve of the in-situ cast ILB had not before been constructed in a dual lane road configuration, and certainly never before in such a harsh, marine environment.

TIME CONSTRAINTS

Initially, the NSW Minister for Roads stated that the road would re-open within 2.5 years from the date of closure in August 2003, providing a deadline for re-opening no later than February 28th 2006. Given that, at that time, the RTA and government did not have a solution to offer the community, the fact that the road was reopened on December 11th 2005, three months ahead of the Minister's official deadline is a remarkable achievement.

The Assessed Risk Level at time of closure was Level 1 – a 1:50 risk of a fatality from a rock fall. The target "acceptable" risk level was ARL 3 – a 1:10,000 risk level. The LHD team achieved an overall ARL of 4, with several elements of the project at ARL 5. ARL 4 is 1:1,000,000 chance of a fatality from rock fall, an exponential improvement on the old road and beyond any expectations of the client.

With the contract only awarded on 12th December 2003, the actual design and construction process, on this immensely difficult and challenging site, was completed in only 24 months almost to the day.

SYSTEMS COMPLEXITY AND SYSTEMS EFFICIENCY IN DELIVERY AND OPERATION

The team adopted common systems and procedures which integrated the different approaches and functions of the team members.

From the outset, all members of the Alliance Team – drawn from the four members of the alliance – were housed in a common office, separate from the offices of the member companies, with a common mindset and purpose. The Alliance Charter embodied the principles of "no blame" culture and the concept that "there is no such thing as a stupid idea".

This cooperative relationship, alien to most construction contracts where client and contractor normally operate from a position of distrust, was a refreshing change. RTA was aware of the potential benefits of alliance-type contracts and was keen to explore this, and was pleased when the alliance process and outcomes far exceeded their expectations.

Involvement of many RTA personnel in the team, throughout the project, greatly facilitated this approach, as aspects of quality control in the construction process, such as concrete testing, were completely transparent.

COMMUNITY, ENVIRONMENT AND HERITAGE CONSTRAINTS

A Community Consultative Committee was formed as a primary communication channel resulting in adoption of community requests, such as locating the walkway/cycleway on the seaboard side of the structure and selecting the bridge railing.

Regular mail-outs, explanatory brochures and regularly-updated local photo displays kept the community informed of progress, and organised open days staffed by the Alliance team involved them in the process.

Great effort was exerted to prevent site run-off entering the ocean. The revetments were lined with geofabric with numerous settling ponds while other anti-erosion methods, including hydromulch, gabion walls and rock armouring of culverts were included during site establishment.

It was acknowledged that some short term disruption to the marine littoral communities would occur with the establishment of the revetment, constructed from rock similar to the natural rock falling into the ocean from the cliffs above. Replicating the existing haphazard nature of the rocky sea floor created crevices and rough natural surfaces which promoted the rapid re-establishment in the area by marine organisms with no long term detrimental effects.

The southern-most pier of the BCB is within 20m of the sealed entrance to the original Coalcliff Colliery. Relics in the area included a heritage-listed boiler, preservation of which required the pier cap on the southern-most pier to be relocated.

A stand of 13 ornamental Norfolk Island pines in the northern amphitheatre were also adopted as a constraint at the suggestion of the local community, for whom they had some cultural significance.

The Alliance team also managed to include other significant benefits for the local community, such as the 2m walkway and cycleway on the seaward side of the bridge which nonetheless added costs to the project which had to be incorporated. The extension of the bridge pedestrian walkway through the northern amphitheatre and around the northern headland was requested by the client and treated as a variation on the original design.

RISK MANAGEMENT

Perhaps the biggest risk involved with the project was the acceptance by the client of the necessity for adoption of the alliance contract delivery method. This provided far greater exposure to risk for the client, especially as RTA became a member of the alliance providing staff and logistical support.

The steeply-sloping nature of the site, and the nature of the project's various elements, provided considerable potential risk of injury and death to the workforce employed on the site.

Regular risk workshops were held and facilitated by an external party (a member of the wider RTA) to ensure no risk surprises occurred.

One example of the innovative approach to risk management by the LHD team was the acquisition of a side-slope radar (SSR) commonly referred to as ground-probing radar. This technology was developed for the open-cut mining industry where the ability to predict rock falls from unstable cut slopes is essential for the ongoing safety of mine workers.

LEADERSHIP AND MANAGEMENT OF PROJECT DELIVERY

PROJECT TEAM RELATIONSHIPS, INCLUDING CLIENT, EMPLOYEES, CONSULTANTS AND SUBCONTRACTORS

Critical to the success of any Alliance is the ability of staff to embrace the principles of alliancing, leading to performance improvements and superior interpersonal relationships.

The RTA, involved as a partner in the alliance, had previously unthinkable access to the engineering design process, cost accounting and quality assurance methodologies. This access gave RTA management increasingly confident assurance that all aspects of the contract were being managed effectively, appropriately and expeditiously.

Major subcontractors were offered a Sub-Alliance contract, giving them ownership of their contribution and improved chance of performance rewards. Geotechnical stabilisation contractor Geovert was one such contractor who had only ever previously operated in traditional cost-price tendering contracts.

They, too, entered wholeheartedly into the spirit of the alliance process, volunteering safety-training in single-rope techniques and especially the nature of single-rope rescue techniques. Through their involvement in the performance rewards scheme they were able, through successful and expeditious completion of their contract, to take away more then they might have done due to the gainshare reward system.

Employees were involved through regular toolbox meetings and adoption of the Safe Act Observation process, making them responsible for each other's safe behaviour. The efforts of the safety team earned the respect of the workforce, further encouraging buy in to the safety program which led ultimately to the zero LTI figure.

Significant gainshare was earned by the Alliance partners during construction, highlighting the success of the Alliance in achieving 'best-for-project' performance throughout. From a possible 100% of the reward 'pool', 78% of gainshare targets were deemed by the independent Performance Review Team to have met or exceeded targets and rewards were distributed accordingly.

INNOVATION IN THE DEVELOPMENT AND DELIVERY OF THE PROJECT

This project has redefined the way the RTA delivers projects. It was the first road construction alliance for RTA and a measure of the success of this team's approach has been the subsequent adoption of the alliance delivery methodology in road construction contracts on Windsor Road Duplication, two contracts forming part of the Hume Highway Upgrade, and the Coopernook to Herons Creek Upgrade on the Pacific Highway. Still other RTA alliance projects are in the pipeline, including the Pacific Highway Upgrade at Ballina and the Iron Cove Bridge duplication.

The propitious outcomes of the LHD Link Alliance encouraged support for this method of contract delivery. The LHD Link Alliance demonstrated it could be made to work successfully to the RTA and convinced RTA management their initial risk exposure had been profitably and expeditiously managed.

Furthermore, the experience of membership in the LHD Link Alliance has had a profound effect on the way RTA departments interact. After an informative and enlightening 'what did we learn from this project' debriefing session, heads of various divisions of the RTA went away committed to implement some of the principles and behaviours learned on the project into their normal daily interactions.

Management Innovations

- Foresight by the client in embracing their first ever Alliance as a means to expedite and deliver an optimum project solution
- Pro-active management of community, environment and heritage issues achieved a record three month approval time for the Review of Environmental Factors
- Adoption of non-adversarial preliminary project solution workshops involving all potential contractors provided for a richer exposure of alternative ideas, but also lead to the implementation of Multiple Criteria Analysis to eliminate non-workable solutions from the initial 70, down to 29, then down to the final four, from which the eventual 'preferred solution' was drawn
- Installing all the Alliance team members in a dedicated office enabled them to work together for the project as a team
- Adoption of a project logo, while not initially encouraged by the client, became symbolic of the identity of the workforce and management team as a unit separate to their actual employers, encouraging loyalty to each other, rather than the more usual suspicion and mistrust evident in D&C contracting
- Branding as 'LHD Link Alliance' of safety equipment and workplace clothing, even vehicles and community interaction materials, distanced the team from their actual employers but conversely brought them closer together as a united team, focused on best-for-project outcomes
- Provision of review, checks and balances by the Alliance Leadership Team kept a tight rein on fiscal responsibility, enabling the LHD team to focus on the project as, under the alliance system, contracts are open book, with costs and profit shares known on all sides

Environmental & Cultural Heritage Innovations

- Voluntary adoption of natural and cultural heritage items like the historic steam boiler and Norfolk Island pines as design constraints would not normally be possible under a straight D&C contract
- The design and fitment of a proximity alarm on the concrete batching plant Front End Loader prevented excessive noise from the vehicle's standard reversing alarm affecting the local community while maintaining workplace safety
- A small population of the Drooping She Oak (Allocasuarina verticillata), a species primarily endangered by reduction in population size due to habitat loss in the Northern Illawarra, was found on the site. Although the small population identified was not endangered by the project, the Alliance team commissioned the collection of seed and propagation of 5000 seedlings for planting throughout the region to assist with the ongoing survival of the species.
- On-site flocculation treatment of pile-boring water enabled safe ocean discharge, rather than the standard practice of off-site dumping in special waste treatment facilities, greatly reducing the amount of waste needing to be dumped and preventing pollution of the marine environment from pollution by untreated pile water discharge
- The construction of the BCB included run off scuppers at three metre intervals designed to spread the impact of stormwater run off, preventing localised concentration of fresh water that could result in an appreciable decrease in salinity in the intertidal zones, thus minimising potential harm to the local marine environment.

- Construction of the revetments sought to prevent site and storm water run off contamination of the coastal zone through the use of geofabric placed behind the revetment, trapping any silt and solid matter. The marine habitat created by the revetment was so successful that NSW Fisheries requested we leave it behind rather than demolish it as had been intended.
- Additional stabilisation was performed at the base of the cliff line, within the storm surge zone, where the claystone layer was being undercut by wave action by application of mesh reinforcing and sprayed concrete

Technical Innovations

- Strictly controlled management regime for concrete production achieved game-breaking quality evidenced by a concrete Coefficient of Variability equal to 5.2 and 5.7% for the ILB and BCB respectively. At the time, industry best practice sat around 8-10% and industry average at about 12%.
- Modifications to the traveller head preventing concrete separation during pouring by allowing the kibble much closer to pouring location; also enabled easier access for steel rebar, post-stressing wires and large sections of formwork through 5m x 5m gap created for this purpose in the traveller head, all of which contributed to shorter traveller turnaround times and the improved quality of finish
- Off-site construction of large sections of BCB formwork and the travellers prevented height safety risk for employees; prevented site congestion; reduced set-up time of the travellers and demonstrated ‘world first’ innovative methodology
- Installation of a high-flow hydraulic pump rather than the supplied pump unit significantly improved traveller turnaround times
- Use of HDPE plastic ducting for post-tensioning cable ducts helped prevent corrosion and improved installation times
- Adoption of internationally recognised design codes (AASHTO and Eurocode) to supplement the Australian Bridge Design codes to ensure the most efficient design was achieved. This was required as the Australian Bridge Design code provisions for shear and torsion are not applicable to the large box sections of the BCB.
- Use of variable lap stirrups in the webs of BCB to avoid every bar having a different length due to the curved soffit of the bridge. To overcome the code restriction on the use of laps in web, a variable lap hooked splice was developed that satisfied construction requirements and code compliance.

OH&S Innovations

- Use of access bridges to pier heads improved safety in a number of ways: preventing unnecessary ground level vehicle and staff movements at the pier bases along the narrow, slippery and dangerous shoreline roadway; prevented trip and slip hazards from movement up and down scaffold stairs exposed to ocean spray and, by speeding up access to the pier heads prevented accidents caused by employees rushing to complete tasks they now had more time to perform more safely
- The use of ground-probing side-slope radar to detect imminent rock falls added appreciably to employee satisfaction with OH&S program and helped convince them that management was serious about their safety

- Use of electric vibrators for concrete compaction (rather than petrol-powered) inside the BCB improved air quality, manual handling risks and safety for employees operating the vibrators and those working around them
- Provision of voluntary skin-cancer screening for all employees was both a preventative measure and heightened awareness of the risk
- Use of an innovative Proximity Alarm rather than the traditional ‘reversing alarm beeper’ on the batch plant Front End Loader assisted worker safety without noise pollution affecting local residents
- Implementation of Safe Act Observation program helped achieve zero LTIs by providing more opportunities for buy-in to the safety program and hazard awareness

MANAGEMENT CONTRIBUTION OF THE ENTRANT IN THE DESIGN PROCESS

The early introduction of artistic design review, lead to modifications to the twin-blade construction for the ILB, which would ensure the same depth structure as the BCB, providing seamless transition from one section to the other and a more lucid and aesthetically complete design solution.

The entrant’s research into the design and construction of the BCB component involved a field trip to a BCB under construction in Norway, as a result of which that bridge’s designers, Aas Jakobsen, were engaged by the alliance team to independently check the BCB calculations and specifications.

PLANNING AND CONTROL OF CONSTRUCTION OPERATIONS

To conceive, identify, obtain approvals, design and construct a significant infrastructure project in two years – starting from a blank sheet of paper – is indeed remarkable.

Key Dates

Road closure and Request for Proposal:	29 August 2003
Proposal submission:	29 September 2003
Proponent & proposal workshops:	21-24 October 2003
Advised preferred proponent:	5 November 2003
Executive Alliance agreement	13 November 2003
Alliance / Client Contract signed	12 December 2003
Stage 1 (Concept Design)	30 January 2004
Review of Environmental Factors (REF)	23 March 2004
Stage 2 (Establish Target Outturn Cost)	3 May 2004
Stage 3 (Completion Target)	29 November 2005
Practical Completion	9 December 2005
Public Opening Ceremony	11 December 2005
Targeted Road opening	28 February 2006

Other than the government’s stated re-opening date of not later than February 28th 2006, all the other target dates and milestones were set internally by the alliance.

Occupational health and safety management

The LHD Link Alliance commenced the project with an aggressive target of zero lost time injuries. In over 285,000 man-hours no Lost Time Injuries were recorded and only three minor injuries involved off-site medical attention, none of which resulted in the loss of a shift.

Apart from the previously mentioned Side Slope Radar, employed early in the project to provide early warning of the possibility of rock falls, other employee safety measures included the provision of free skin cancer screening.

Almost 100% of the workforce availed themselves of this opportunity and, while most were given a clean bill of health, two people were found to have possible developing melanomas which were subsequently successfully treated by the employees' own doctors.

The standard-fitment reversing alarm beeper on the Front End Loader (FEL) in the concrete batching plant was particularly onerous for residents directly opposite the plant, yet its operation was mandated to help prevent accidents involving employees working near the FEL.

The solution was a custom-designed Proximity Alarm, similar to those now fitted to many cars, which sets off an audible alarm when something enters the vehicle's proximity.

Industrial relations management

Proactive management by the construction team of workplace issues, especially safety issues, ensured there were no industrial relations incidents during the course of the project, despite numerous visits from union executives from local Wollongong branches and the existence on site of one especially vocal delegate.

The inclusion of the employees in the Safe Act Observation program, along with the provision of regular two-way toolbox feedback sessions enabled pre-emptive solutions to potential problems to be handled prior to their becoming an issue.

For example, a query raised at one toolbox about provision for rescue of employees working on the pier head in height safety harness, should they slip and fall from the platform and remain suspended from their harness, resulted in the invitation of all branches of the Emergency Services to the site to review their requirements and concerns should this occur and they be asked to deal with it.

It was further resolved as a result of this visit to purchase a piece of specialist equipment called a Harness Rescue System from the height safety equipment supplier, and all employees working in the environment were trained in the use of the system.

USE AND DEVELOPMENT OF NEW TECHNOLOGIES AND PRACTICES

As outlined previously, there were many innovative solutions utilised on the LHD Link Alliance project, many of which were new technologies while still others were significant developments of existing technologies or practices.

- Use of the Side Slope Radar from Ground Probe was technology new to the construction industry, although previously used in the mining industry
- The Proximity Alarm to the batch plant FEL was technology not used before in the construction sector, being adapted from the automotive industry

- The Safe Act Observation program was also an import from the mining industry, adapted for use on a construction site
- The use of durable plastic, crush-resistant, High Density Poly Ethylene (HDPE) tubing for the post-stressing cables rather than the previous industry standard, wound metal tube, provided a significantly increased resistance to crushing and corrosion
- Modifications to the cross-bracing on the European-designed formwork travellers enabled concrete to be poured closer to its eventual location, preventing separation caused by long drops and providing for better compaction and a higher density for the concrete for better corrosion protection of the rebar
- These modifications also provided a larger ‘working window’ in the head of the traveller, enabling larger sections of the internal formwork to be constructed and hoisted into position quickly and efficiently, saving time and congestion on the traveller and improving safety for the workers
- Modifications to the formwork fixing system on the travellers resulted in significantly less penetrations of the BCB deck, significantly improving the speed of relocation of the travellers; provided for a more aesthetically pleasing finish and greatly reduced reworking of blemishes caused by the filling of numerous penetrations
- Installation of an improved, high-flow hydraulic pump to the traveller units greatly improved traveller turnaround times, resulting in faster progress on the critical path leading to early completion
- The off-site production of large sections of formwork, then made onsite into even larger sections, enabled huge pieces up to 23 tonnes to be hoisted by the tower crane in the initial launch of the travellers, greatly improving height safety, formwork construction time and traveller erection time. According to the traveller manufacturer, who has not seen or heard of this method previously, it is another ‘world first’ by the LHD team
- Design and installation of pier head access bridges saved time and prevented potential injuries, providing benefits to both employees and management by speeding up movement of workers and thus the flow of work without compromising safety by having them running up and down scaffold staircases
- The steel launch nose of the ILB was redesigned and modified to suit the tight curvature of the 150m radius curve, which required it to be ‘kinked’ to the right in order to properly land on the launch bearings on top of the next pier as each bridge segment was launched out, another world first
- Modifications to the design of the pre-cast concrete parapet sections enabled them to be quickly and easily installed on the ILB where they acted as a safety barrier during the launching of subsequent sections of the ILB. This was a technique previously pioneered by Laing O’Rourke (then Barclay Mowlem) on the Woronora ILB. There the parapets had been made in a single casting, but this made them difficult and somewhat dangerous to handle on site, as they were delivered upside down and had to be rotated through 180 degrees prior to installation. The modification saw them cast in two sections so they could be erected more safely, with a small tie-section bolting them together and hold-down bolts fastening them to the bridge deck
- Installation of an impressed current cathodic corrosion prevention system (SAVCOR) involved a significant investment but was deemed essential in order to meet the client’s design requirement of a 100-year lifespan for the project once completed, with minimal maintenance required

The independent Performance Review Team (PRT) concluded in their assessment of the concrete quality that the sorptivity (or mix design), which uses the Volume of Permeable Voids (VPV) as a benchmark, had achieved a measure of less than 12 percent VPV against the 13.5 percent set as the Minimum Condition Of the Specification (MCOS). The VPV is directly related to the ability of chlorides to penetrate the structure. The lower the VPV, the less permeable the concrete, the better it will withstand chloride attack, significantly reducing the likelihood of future maintenance issues.

The other measurement of concrete quality highlighted as significant by the PRT was the Batching Control mentioned previously, which saw the project team achieve an incredible Coefficiency of Variation of less than 6. (Normal is 10-12 and Excellent is 8-10).

This was achieved primarily by the adoption of a limited number of mix designs, and a limited number of alterations to mix design for different areas of the project, greatly reducing the risk of the wrong mix being placed in the wrong area.

Out of the total of approx 12,000 cubic metres poured on site, less than one half of one cubic metre was rejected. For the RTA, this was deemed an exceptional achievement. The mix control coupled with exceptional placement management processes saw the PRT deliver the finding that the Alliance had exceeded the required specification for concrete quality, finish and placement.

TRAINING AND DEVELOPMENT OF PROJECT RESOURCES

Under the Alliance contract, a Training Management Plan was implemented to ensure necessary and additional training would be provided to those working on the project and affiliated with the contractors.

Aside from the previously mentioned exhaustive Induction Training; the Safe Act Observation Program and Job Safety Analysis, which essentially trained workers in how to check they were working safely; Harness Rescue Training and Basic First Aid training, there were the usual compulsory workplace related training programs. These included training for those working with cranes, directing traffic on and off site, fire training, emergency response training and specifics such as training in the use and maintenance of UHF radios and communication protocols.

All members of the alliance took the opportunity to rotate cadets and junior site engineers through the project to provide them with relevant experience on this type of project and to involve them and ground them in the alliance process.

All staff coming onto the project received Alliance Induction training so that new starters could be aligned to the behavioural principles and alliance objectives.

OVERALL OUTCOMES ACHIEVED

ACHIEVEMENT OF TIME, COST, QUALITY AND SAFETY OBJECTIVES

Time

The client’s original goal was to have the road reopened to traffic by the end of February 2006, 30 months after road closure. The aggressive game-breaking goal (with a risk factor of 50%) set by the Alliance team was an intention to reopen the road by 29th Nov 2005. Practical Completion was achieved on the 9th December only 10 days after the game-breaking target and three months ahead of the published completion date. The official opening was on the 11th December 2005.

Cost

The project's total cost was aimed at $48m. Final cost was $52m – only an 8% increase and very close to adjusted Target Outturn Cost and, more importantly, to the client's satisfaction. The additional components like the combined pedestrian walkway and cycleway added significantly to the value for the local community, while the early completion enabled the road re-opening to occur immediately prior to Christmas, further enhancing the value for the local community.

The extension to the walkway/cycleway to the north through GD4 and 5, plus the provision of a duct through the entire bridge to facilitate laying of electricity utility company power cables, were both client-initiated alterations to the design and were thus treated as a traditional 'variation' to the contract sum.

Considering the alliance contract method attempts to predict the total outturn cost (TOC) including an assessment of all the risks involved, the accuracy of the estimates against the reality is truly remarkable and sets a new benchmark for this process.
This is even more remarkable when it is understood that the risks were analysed using a Monte Carlo technique and that all were given a factor of 50% probability of achievement of target.

Given that potential for deviation from the original budget was very real due to constraints mentioned elsewhere, the client's perception of value for money was of paramount importance. Of similar importance was acceptance by the local community where a survey showed a 98% satisfaction level with the finished project.

Quality

The Sea Cliff Bridge redefined what is possible – and achievable – in terms of concrete quality control. As outlined previously, the independent Performance Review Team concluded that the Alliance had exceeded the required specification for concrete quality, finish and placement. This is one aspect of the project that the client, RTA, was particularly impressed with, during the construction process as a member of the alliance, not just after the event.

Safety

Similarly, all safety objectives for the project were achieved, the measurement of 285,000 man hours without a Lost Time Injury not wholly remarkable until one recognises the nature of most of the work involved height safety issues and operating on a dangerously steep site in an unpredictable natural environment.

Ultimately, the principle goal for the project was to deliver a measurably lower risk level to the public using the completed road. The improvement was a quantum leap in public safety, going from an Assessed Risk Level 1 to an ARL 4 against a contract specification of ARL 3. This altered the probability of death or fatal injury from a rock fall event from 1 in 50 to 1 in a million.

Given that the alliance's self-imposed target was an ARL 5 (which was actually achieved over some sections of the project), to achieve an overall ARL 4 is still a significant level of magnitude improvement in outcome for the client and the general public, even exceeding the contract specification.

CLIENT SATISFACTION AND GENERAL SUCCESS OF THE PROJECT

The client's satisfaction with this project is twofold – firstly the RTA has expressed a level of satisfaction in the Sea Cliff Bridge unmatched by any other project in terms of harmonious relationships, quality control and the complete lack of any hangover issues or quibbles at the conclusion of the project.

Secondly, RTA has demonstrated its approval of the ***process*** rather than simply the project, by entering into a significant number of alliance contracts on other road construction projects elsewhere in the State, primarily as a result of what the LHD team demonstrated could be delivered utilising this process.

The Lawrence Hargrave Drive Upgrade Project redefined what was possible for the RTA in terms of contract delivery methodologies and showed them and the rest of the industry what is achievable under this type of contract.

It has set a new benchmark not only for quality of finish and timeliness in delivery of bridge construction projects, but has also raised the bar in terms of what is possible within an engineering project that attempts to meet both the client's requirement for a cost-effective solution and the contractor's requirement for a healthy bottom line – while still providing additional value through design innovation and construction best practice.