

LAING O'ROURKE

2016 LAING O'ROURKE

AUSTRALIAN CONSTRUCTION ACHIEVEMENT AWARD

TECHNICAL PAPER



ENGINEERING THE FUTURE



LAING O'ROURKE

MOOREBANK UNITS RELOCATION PROJECT



LAING O'ROURKE IS A \$7 BILLION INTERNATIONAL ENGINEERING ENTERPRISE, FOUNDED ON MORE THAN 170 YEARS OF EXPERIENCE.

With 50 years of involvement in Australian construction and infrastructure – including a decade under the Laing O'Rourke banner, Laing O'Rourke has played an instrumental role in the delivery of major infrastructure projects for clients in the defence, transport, oil and gas, resources, health, commercial and industrial sectors.

Laing O'Rourke specialises in the planning and delivery of defence infrastructure projects in Australia and was listed as one of the ADM Top 40 Defence Contractors for 2015. The organisation is currently engaged in the delivery of a number of major projects for the Department of Defence in Queensland, New South Wales, Victoria and Western Australia.

In 2011 Laing O'Rourke was engaged by the Department of Defence as the Managing Contractor for the Moorebank Units Relocation project – the largest single site Australian Defence capital works project since World War II.

As Managing Contractor, Laing O'Rourke was responsible for the complete relocation of Defence facilities and assets from a 190 hectare site at Moorebank to a 110 hectare site at Holsworthy Barracks.





Laing O'Rourke's innovative approach to project and supply chain management, high-security delivery methods and detailed stakeholder management ensured the successful delivery of this project.



Moorebank Units Relocation Project



KEY PROJECT PARAMETERS

Outcomes achieved against planned targets for key project parameters

The precinct approach ensured the efficient management of all aspects of the design and construction phase. The sheer scale of the project meant that without the precinct model, the risk of delay or inflated costs were too high.


The delivery of this project was fast paced and spread over two large geographical areas, as such the replication delivered through Laing O'Rourke's use of Digital Engineering

(DE) and Design for Manufacturing and Assembly (DfMA) were also major contributing factors to its success.

The successful completion of the project was reliant on precision planning with clear targets and strict key performance indicators (KPIs) and milestones set throughout the delivery phase.

Absolute assurance of programme was paramount as any delays could impede

Australia's military capability and delay the progression of the planned freight infrastructure project on the Moorebank site, and as such Laing O'Rourke had contingencies in place for every possible scenario to ensure the client's requirements were met.



The Moorebank Units Relocation project was delivered on time and under budget for a client that sees the project as the benchmark for delivering all major construction and engineering schemes in the future.



A large contributor to Laing O'Rourke's successful delivery of the Moorebank Units Relocation project was the strategic decision to split the delivery into six precincts:

- Holsworthy Barracks Entry Precinct
- School of Military Engineering (SME)
- Living in accommodation
- Liverpool Military Area, Gym, Pool & Mess Area
- 5 Brigade & Training
- Infrastructure / Enabling Works



SAFETY

Laing O'Rourke strives to create a culture of world-class safety through visible leadership, clear expectations, streamlined systems standards and robust risk assessment.

Our approach to health and safety is based on the idea of personal commitment and empowerment. We believe everyone has a right to be involved in safety decision making that enables them and those around them to return home safely every day. However, ultimate accountability for the safety and wellbeing of our workforce rests with our senior executives, who uphold their obligations through a resolute commitment that includes the active management of our health and safety agenda.

Throughout the delivery of MUR, Laing O'Rourke introduced a number of programmes, processes and procedures to ensure the safe delivery of the project.

Mission Zero and other safety programmes



Mission Zero was Laing O'Rourke's behavioural safety campaign which significantly reduced our DIFR (Disabling Incident Frequency Rate, a measure of incidents recorded in

every one million hours worked) from 15.2 at the programme launch in 2011 to 2.8 in early 2015.

Laing O'Rourke's commitment to safety was demonstrated with the site-wide roll-out of Mission Zero behavioural safety training and *SafeSpine* training (focusing on musculoskeletal safety) for all employees, supply chain members and client representatives as part of their induction.



Laing O'Rourke's *Safety in Design* (SiD) system was also implemented on MUR during the planning phase (design development). This system makes clear the health and safety responsibilities that must be managed and monitored by consultants and designers working for Laing O'Rourke, directly or indirectly, and sets out a consistent process for safety in design.

Under SiD it was a requirement that all consultants and designers were issued with a copy of the SiD Guidelines and the "10-Steps to Health and Safety Management".

The "10-Steps to Health and Safety Management" sets out a range of minimum standards consultants and designers must adhere to at every level of a project, from organisation to planning and measurement through to audit and review.

It was a pre-requisite for any consultant or designer to sign up and express their full support, and that of their company, to these standards before they were appointed by Laing O'Rourke.



4,400,000

Number of hours worked by the team, including subcontractors.



Workplace Tragedy – A family support group

During the delivery of the project, two representatives from Workplace Tragedy, a family support group, visited site and presented to around 1,200 members of the workforce.

This organisation represents families who have lost loved ones in the NSW construction industry, and they visited our site to deliver an important presentation about the long lasting grief and long-term impacts of workplace incidents. Following their presentation, the organisation's Secretary, Wendy Lark, sent a letter to Laing O'Rourke's Global Chairman Ray O'Rourke congratulating him on the outstanding safety systems and culture they observed on site.

Engagement of subcontractors and suppliers

At the beginning of the project Laing O'Rourke held an Industry Briefing and more than 500 representatives of local industry attended. The briefing provided subcontractors and suppliers with vital information about how the project would be delivered, how and when packages would be released to tender and



The project management is incredibly innovative in their techniques, and have developed a health and safety culture that is second to none I have ever seen in the last 7 years.

**Wendy Lark, Secretary/Facilitator
Workplace Tragedy**

importantly started a critical dialogue between the client, Laing O'Rourke and our delivery partners.

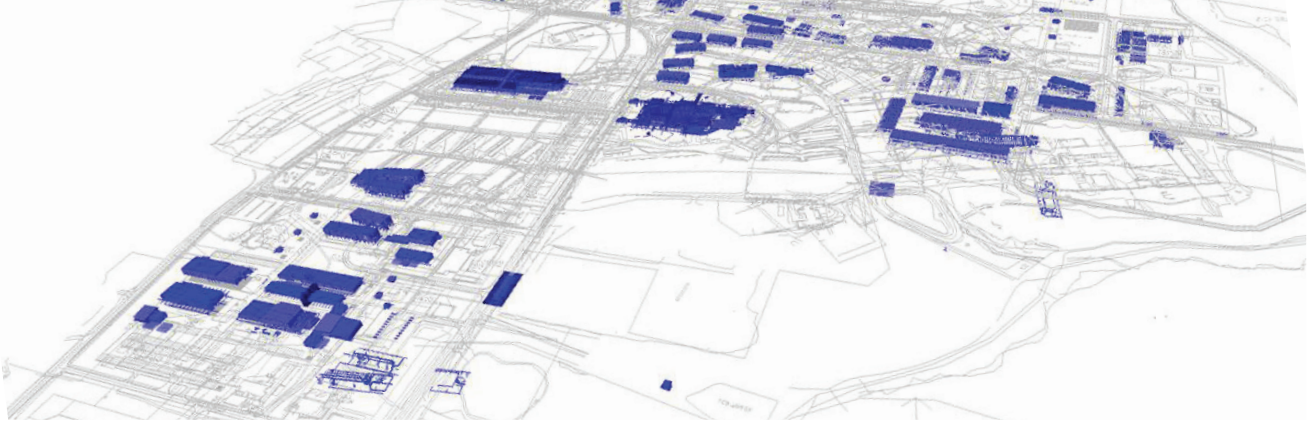
There were 300 subcontractors engaged in the delivery of MUR, including other Tier 1 construction companies.

We implemented a rigorous approach to the selection, engagement and onsite management of subcontractors to ensure the high standards of Laing O'Rourke were maintained in

relation to safety, quality and environmental management.

The key elements of our approach to the management of subcontractors and suppliers were:

- Focus on the engagement of reliable, trusted and performance-oriented subcontractors and a materials supply chain to provide certainty and confidence in achieving programme milestones and quality standards
- Subcontractors were selected using rigorous criteria to ensure they met Laing O'Rourke's high standards of safety performance, environmental performance and quality control
- All subcontractor personnel were subject to Verification of Competency assessment, site-specific inductions and, where necessary, site-specific training to ensure they were suitably trained for the specific tasks and environment found on the project
- Supervision and coordination of subcontractor's activities onsite by the relevant Project Engineers, Foremen and the Senior Construction Manager.



By employing the DfMA approach, Laing O'Rourke was able to eliminate inefficient processes and maintain greater control over the project's risks.

The senior management from each contractor engaged on the project met directly with Laing O'Rourke's project leadership team at the award of contract to:

- Review and agree on the projects safety requirements.
- Go over the findings from the supply chain audit and agree on any actions arising.
- Develop a safety quote / charter for the project, to be displayed in the training centre

The most senior manager from each subcontractor attended Laing O'Rourke's Mission Zero behavioural training with their workforce and participated in Laing O'Rourke leadership engagement programme.

This created an environment where people understood each other's values and behaviours, created a relationship from the outset that allowed the diverse businesses and personnel to work toward a common goal.

Digital Engineering

Digital Engineering enabled the project's safety risks to be more effectively communicated to the site team and enhanced the awareness of health and safety to all site personnel.

At the beginning of the project, the team opted to use Laing O'Rourke's enhance Digital Engineering expertise to provide clear visual outputs demonstrating the health and safety risks associated with activities on site as identified in the Project Risk Assessment.

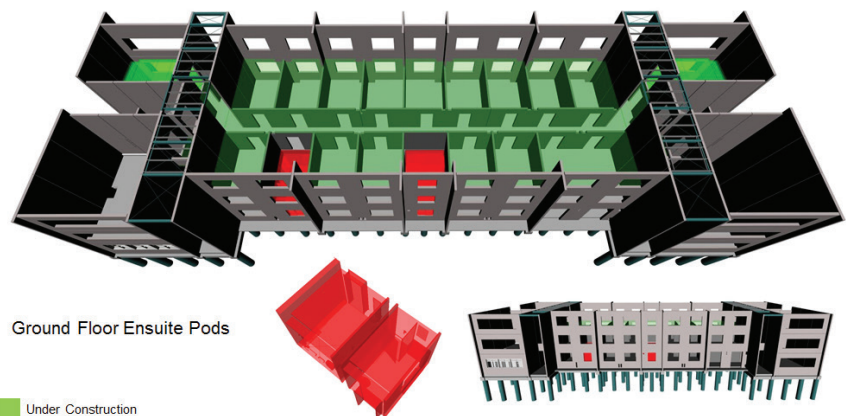
A model representing the site conditions during specific work activities was developed to visually communicate each of the safety risks identified in the Project Risk Assessment. Outputs were generated to support the Precinct Site Induction briefings.

Outputs generated from the model visually communicated safety risks in context of the site and surrounding construction activities. New starters

Design for Manufacture and Assembly (DfMA)

To minimise risk on-site Laing O'Rourke adopted designs which relied on off-site manufacture including precast concrete and structural steel, 250 bathroom pods, curtain walls, ceiling panels and prefabricated service components.

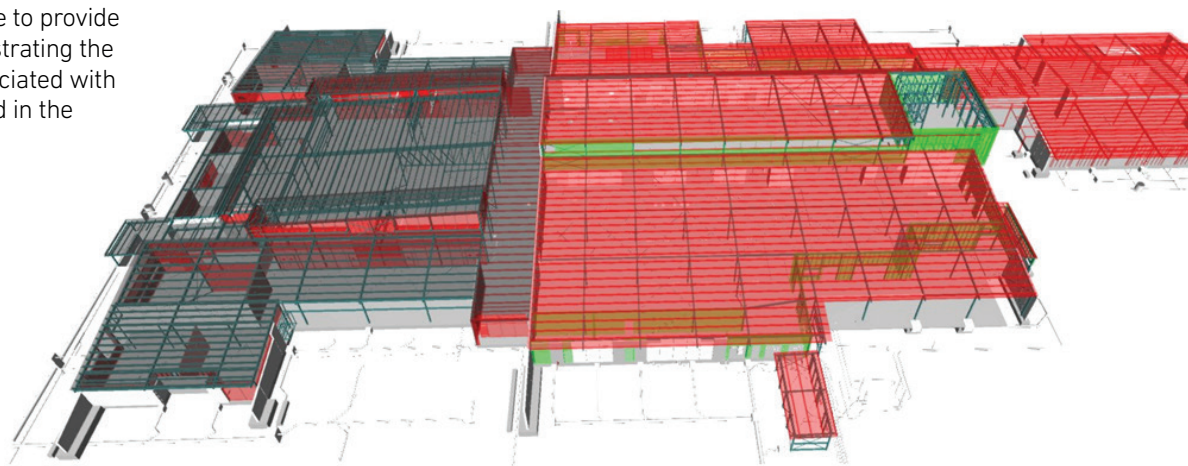
The success of the constructability and improved safety and quality on



were instantly familiarised with site conditions and more effectively informed of the potential safety hazards prior to commencing works.

Our approach provided enhanced visual communication of site safety risks at Precinct Site Induction briefings.

MUR are now benchmarks for other Laing O'Rourke projects. Prefabricated building options reduce the risk of OH&S issues by reducing the number of hours required on site and increasing the quality of the product.



TIME



AUSTRALIAN ARMY MUSEUM
OF MILITARY ENGINEERING

To facilitate the fast-track construction programme Laing O'Rourke utilised a number of innovative management and delivery techniques.

The Commonwealth Government had set a firm deadline of June 2015 for completion to ensure it could progress the delivery of a new intermodal terminal on the vacated Moorebank site. Laing O'Rourke completed the project ahead of schedule in April 2015, providing the client with a three month contingency in its overall delivery timeframe.

A clear vision from the beginning of the process, an understanding of the client's needs and our internal approach to uncovering innovative solutions, ensured that target milestones were not only met but beaten on many occasions.

The first buildings due for completion were the Defence Support Operations, Defence Community Organisation, Cadets' Facilities and Cadets' Q Store – all part of the Front Entry Precinct of the wider Moorebank Units Relocation scheme. They were handed over two months ahead of schedule. This allowed the Department of Defence a flexible approach to the transitioning of Defence personnel.

Anzac Day

The project delivery team worked around the clock to ensure the relocation of the Obelisk, a relocated heritage memorial from the School of Military Engineering, was complete and the surrounding area finished and ready for the Anzac Day Dawn Service in 2015, to mark the 100th anniversary of the Gallipoli landing.

More than 1200 people attended the service on the day, including 86 representatives from Laing O'Rourke.

Communication of Planned vs Actual progress via 4D Models

A 4D model was utilised to reflect actual progress of works completed against planned, allowing the team to better evaluate the impact of changes to the programme methodology. The model was developed in Navisworks with the planning team's Program to Build

to virtually demonstrate the planned construction sequence.

Each month, the Planning team synched live information from Primavera 6 with the 4D model, allowing both the planned and actual works to be visually monitored.

This allowed the project team to rapidly understand the program status and instantly highlight deviations from the planned programme methodology to better assess and evaluate forecast works.

There were eight staged completion dates throughout the project, seven of which were linked to KPI incentive payments. Laing O'Rourke met all nominated contractual dates.

Clear visual outputs supporting the Planning Team's assessment of works at Program and Contract Reviews, and allowing the wider team an instant visual understanding of programme status.

One problem that was resolved using the BIM and digital engineering was the early detection of a clashed service. In the planning phase it was discovered by the consultants and the construction team that the kitchen exhaust ductwork would clash with the steel brace.

The team redesigned the bracing for that particular bay of structural steel to allow the kitchen exhaust ductwork to be installed without any clash or other trades in the way. This solution saved time on site, saved re-working of any structural steel on site as the problem was found on the drafting table some six months before the problem would have been discovered in the field.

Managing a fast-tracked design

The design included 80 buildings and structures designed to a fast-tracked programme. Digital Engineering and standardised detailing was used to support the process.

To facilitate the fast-tracked delivery and minimise labour on-site, designs were adopted which relied heavily on off-site manufacture. These included precast, structural steel, bathroom pods and prefabricated services components.

BIM was also used extensively for clash detection (in 3D), construction sequencing (in 4D) and cost planning (in 5D). Over 400 individual BIM models were created, fully documenting the project in Revit 3D and providing Defence with a facilities management tool (Ecodomus) to be used after completion.

As a large project being delivered simultaneously on multiple fronts, several subcontractors for one trade discipline were also established. The standardisation of components ensures commonality of construction between the precincts. At one stage during delivery, there were 96 separate components of the project being delivered concurrently to ensure maximisation of time and cost.

A major component of the project involved the relocation of the School of Military Engineering (SME) precinct. The new precinct provides a TAFE-style campus for military engineering training within the Australian Army.

The relocation of the SME was completed within six weeks. Laing O'Rourke worked closely with the client to ensure the school did not lose any training days during the relocation and has since been able to achieve greater efficiency in the training deliverables in the new efficient facilities.

COST

Cost certainty throughout the project was high with the project spending well ahead of forecast cash flows, giving Defence the ability to manage their cash flow effectively.

Laing O'Rourke, as Managing Contractor, was responsible for the project from concept to completion. We worked closely with the Department of Defence throughout the departmental and parliamentary approval phases to demonstrate value for money and secure the necessary public funding.

From the outset, the delivery team used the digital engineering models to develop 4D sequences, providing greater cost certainty and transparency.

Laing O'Rourke adopted an integrated approach to design in the Planning Phase that focused on optimising constructability and value for money for Defence.

The team completed 90 per cent Detailed Design for more than 80 separate facilities in approximately 14 months. They also facilitated the expedient procurement of trade contractors in the Delivery Phase. This was heralded as an extraordinary achievement by the client.

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Value engineering

Value engineering was conducted through design workshops, user consultation and engagement with specialists who produced a revised building design for the new museum building that was signed off by users.

The building was reduced from 13,000m² to 6,200m² and the build cost from \$33 million to \$20.2 million, saving the client considerable money.

The project reached a peak spend of \$45 million per month or \$1.6 million per day and at completion was delivered \$50 million under budget.

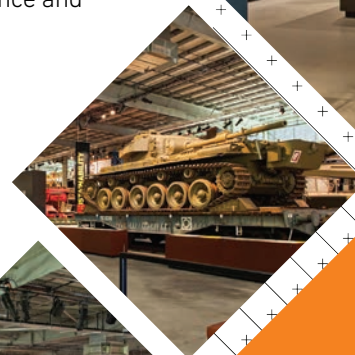
the engagement of key specialists in the field to ensure the project met the stringent and rigorous requirements of Defence and at all stages represented value for money to the Commonwealth, ultimately being delivered well under budget.

Design

The process involved staged design submissions for all components of the project and presentations at 5 per cent, 30 percent, 50 percent, 90 percent and 100 percent completion to users and stakeholders to ensure scrutiny of the cost plan to ensure value for money for the Commonwealth.

The construction programme was also developed during the design stage to ensure appropriate staging and minimal disruption to the army's activities. The result was the delivery of exceptional value for money for the client.

Value for money is a key driver for the commonwealth, Laing O'Rourke, at all stages through the design and into the construction process, evaluated and analysed the approach through benchmark data, previous performance and



QUALITY



Laing O'Rourke has an established Quality Assurance (QA) system currently as part of the company's overall Business Management System, which is maintained and regularly independently certified by SAI Global Certification Services Pty Limited. Laing O'Rourke's system has been continually certified to the quality management system standard since 1991.

It has been designed to control the activities critical to the successful completion of all work. It defines the policies and procedures for the successful execution of our activities from estimating, tendering, procurement, quality and design, through to project completion.

Laing O'Rourke developed the overall Quality Management System that was implemented across the site and ensured all works delivered by suppliers and subcontractors met quality requirements.

Our Project Engineers were also able to access our Digital Engineering model via iPads to manage quality in real time – ensuring any quality issues were dealt with in a timely manner.

The tablets were used for task completion checklists, project information, task scheduling and issues tracking. This ensured a more streamlined and less bureaucratic management system on site.

We were also responsible for establishing the procurement strategy for the project. To facilitate high-quality work, we ensured that off-site manufacturing for precast concrete, structural steel, bathroom pods and prefabricated services components was central to our design.

Laing O'Rourke operates an integrated document management system on the company intranet, iGate, which sets the minimum operational requirements for all employees. iGate contains procedures and guidelines (which provide a more detailed explanation of the process).

The key Laing O'Rourke document produced in the suite of QA documentation for each project is the Project Business Plan (PBP). The PBP is prepared at the outset of a project, and is reviewed and authorised by the Project Leader. The purpose of the PBP is to:

- Ensure that the needs and expectations of the client are met
- Ensure that the project meets the quality requirements including ISO 9001:2015
- Provide a link between iGate and project specific requirements
- Provide an overview of the quality practices, procedures and guidelines to be adopted and implemented on the project.

The PBP addresses the following issues:

- Organisation, authorities and responsibilities
- Client requirements
- Project objectives and planning
- Purchasing and subcontract work
- Manufacture, fabrication and construction processes
- Human resources, induction and training
- Plant and equipment resources
- Reporting, meetings and recording
- Document, data and records control
- Commercial administration.

ENVIRONMENT



During delivery of the project 54,400m³ or 98,000 tonnes of asbestos was encountered, all of which was managed expertly on site with encapsulation with no environmental infringements.

Laing O'Rourke's goal is to minimise the negative impacts of our operations and maximise the quality of the built environment for future generations.

Asbestos contaminated soil was discovered during bulk earthworks within the Front Entry precinct.

When discovered, work at the site stopped and an investigation was undertaken. A hygienist was engaged to assess the extent of the contamination and retained to assist with the excavation, transport, storage and disposal of the contaminated soil.

To minimise the impact on construction, a temporary location for the material was established within the MUR site and the material transported to that location before final placement at the nominated disposal area.

The material was covered with geofabric and the whole area fenced and appropriate signage erected. After the material was transported to the temporary location the area where the asbestos contamination was found was assessed and certified as being clear, allowing enabling works to continue to completion.

While the material was in its temporary location the site and surrounding area

was monitored for air quality and off-site contamination. No issues were identified.

Across the six precincts there was also 160,000m³ of sandstone unearthed, processed and re-used on site as training media for future Defence activities negating the requirement for imported quarry materials

Delivery of the Infrastructure / Enabling Works precinct involved the demolition and clearing of the entire site in a staged manner which included service diversions for the incoming gas and telecommunications network, services isolation and terminations of the previous Defence assets.

There was a precise planned hazardous material removal from each of the buildings and also areas of decontamination around the site.

MUR was designed to achieve a 4 Star Green Star and 4 Star NABERS ratings in line with Department of Defence project brief.

The project includes a range of initiatives to provide positive environmental

outcomes for the life of the project and for the future. These include the establishment of series of sediment basins throughout the site for the capture of stormwater and the retention of silt. The water was later used for dust suppression and for watering retained stands of vegetation.

Also, a biodiversity offset strategy was implemented, involving the establishment of a secure 90ha area of native vegetation, within the Holsworthy base, to ensure its longevity and to prevent inappropriate uses that could lead to the degradation of the area and prevent it from being available for future generations.

The project completion works include a comprehensive landscape and revegetation strategy designed to enhance existing facilities and to complement the built environment of the new facilities. The design also included a significant and project-wide water recycling facility that provides recycled water for toilet flushing, landscape irrigation and vehicle washing.

STAKEHOLDER SATISFACTION

With more than 3,000 military personnel continuing to use the base during construction, stakeholder satisfaction was vital.

Laing O'Rourke works with all project stakeholders in a transparent and collaborative way to ensure construction impacts are minimised, project information is readily available and community input is sought at appropriate project milestones. Our approach is tailored to each project in order to meet the specific needs of the community in which we are working.

This large and complex project had many additional community stakeholders who had to be led through the design and approvals process to ensure their support. We appointed a community liaison specialist to map the stakeholder engagement process and develop information from the design and construction teams for presentation to the community. This ensured we managed any issues that arose and took a proactive approach to understanding community concerns and developing solutions.

To accommodate budgetary constraints while still delivering the same capability, a detailed analysis of user and stakeholder needs was undertaken and functional areas consolidated to share facilities where practical.

At many stages throughout the delivery of MUR, Laing O'Rourke received praise from the client, the Department of Defence.

While presenting at the 2nd Annual Defence Support Services Summit in Canberra, former Australian Defence Force Brigadier Darren Naumann – who was responsible for the capital works and procurement functions for Defence, was discussing ways to improve outcomes for the Department and what it expects of contractors.

During the presentation, he praised Laing O'Rourke's use of Digital Engineering on the project saying he had become a

personal advocate of Laing O'Rourke's "Build twice – once virtually" mantra.

Using Digital Engineering (DE), Laing O'Rourke also delivered a superior layout at Holsworthy Barracks, providing a seamless interface between the new buildings, increased training capability and cutting travel time between buildings by up to an hour a week for soldiers training at the base.

As a consequence of the bespoke communications strategy, there were no public objections to the Construction Management Plan

Laing O'Rourke implemented Digital Engineering and innovation on the project to provide a number of added benefits for Defence, including:

- Better outcomes through collaboration
- Improved predictability and reduced error rates
- Improved buildability
- Improved efficiency in delivery
- Reduced waste; and
- Enhanced safety

The use of DE has also left Defence with a digital model of the entire base and a project workforce trained in the use of BIM technology and now responsible for leading its adoption on other Federal Government projects.

During construction, Laing O'Rourke also trialled the development of a combined asset model for the mess, gym and pool building. This involved augmenting the existing digital engineering model, through specialist software to link

the building systems and information with live facilities management feeds. The pilot was initiated and funded by Laing O'Rourke in order to gain a better understanding of the technology available.

The trial demonstrated how beneficial it can be for a building's design to look ahead, particularly in producing informed hand-over and take-over documentation for buildings and their systems. In the future, the Department's policy information around tendering new works will be informed by the need for accurate and consistent asset registration.

Laing O'Rourke has continued this relationship with the Department of Defence to further develop its asset management approach – incorporating the entire base within a seven dimensional building information model (three physical dimensions, plus time, cost, energy and facilities management) and has been commissioned to examine the feasibility of using digital engineering to manage the client's activities more broadly.

HERITAGE



From the outset of work on MUR, Laing O'Rourke had a commitment to preserving the important Defence heritage on the old Moorebank site and restoring respectfully on the new Holsworthy base.

The multi-denominational chapel is a beautiful building with key historical significance. The existing sandstone military chapel in the grounds of Steele Barracks at Moorebank was dismantled block by block and re-used in the new chapel at Holsworthy.

The relocation of the museum was the largest relocation of a museum in the Southern Hemisphere in history. The 6,000 square metre Military Engineering Heritage Learning Centre (MEHLC) was designed to display the equipment, tools, documents and stories of the Royal Australian Engineers since its inception in 1902.

The MEHLC contained approximately 200,000 artefacts ranging from equipment that engineers have used in various wars and conflicts over the years such as Centurian tanks, rail carriages and excavators, along with smaller items like medals and photos.

The nature of some of those items demanded specialised attention and as such some multi-level spaces, and in some cases humidified spaces were created to deal with the more sensitive artefacts.


Specialist consultants and removal and 'lift-and-shift' companies were engaged to collect and sift through the artefacts to complete the working museum.

Another complex and historically important task completed was the relocation of a 45-year-old C-130 Hercules military aircraft.

This particular Hercules has been both a base landmark and a piece of Australia's military history, serving the RAAF between 1969 and 2000, flying countless operations until it was honourably discharged and displayed within the grounds at Moorebank more than a decade ago.

The uplifting and relocation of five historical bridges was another important section of work successfully completed. The work was planned with precision and completed in a single weekend. Using cranes, flat-bed trucks with wide load capability, the five iconic bridges were relocated and now serve as an important training apparatus.





The Hercules now serves as an important tool in the training of Military personnel.

SUSTAINABILITY

The MUR project is a fantastic example of best practice for Defence buildings in relation to sustainable design principles and strategy for energy and water management.

Laing O'Rourke had a clear plan for to embedding sustainability into the delivery and operation of the project. Our approach was guided by a commitment to set new standards in environmental, social and economic sustainability on a whole-of-life basis. This commitment was delivered through a robust system that integrates sustainability throughout design, construction and use of the end product, with a rigorous system for tracking progress on targets, and driving innovation and corrective action.

A number of key targets were set and achieved. A key target was to embed sustainability policy goals into all design and construction processes. Digital Engineering and DfMA were utilised throughout the life of the project to reduce man hours, traffic movements, and service clashes.

Widespread consultation with end users was carried out to help derive the best strategy for the building control systems and to assist with understanding how to drive behaviour changes towards the use of air conditioning and lighting systems.

There were a number of client presentations and meetings with the Defence Sustainability Managers and Support staff to develop with them a system to feed into a National Defence Energy and Water Management System as well as a MUR specific Energy Management System (EMS) to allow for the ability to provide for continuous performance monitoring and further improvements once the site is operational.

Environmental Sustainable Design and best practise principles for sustainable design have been incorporated into the design and construction of each of the buildings at MUR to reduce their energy and water consumption as well as their waste generation.

The project has also been benchmarked according to National and International best practise energy targets for aquatic centres, catering facilities and museums.

And as outlined above, all office buildings have been designed to achieve a minimum 4.5 Star NABERS tenancy and base building energy ratings as applicable and to meet the EEGO (Energy Efficiency Government Offices) targets.

The following sustainable initiatives were achieved within the design and delivery of the MUR project:

1. Passive Design Principles:

For this project the passive design approach was utilised to maximise the energy efficiency of the buildings from the beginning which was an innovative approach to the precinct planning.

A macro climatic analysis of the Holsworthy Barracks site was used to influence the design of the new buildings. To capture the benefits of the cooler summer winds from the north east and south directions buildings have been orientated to allow cross ventilation to provide cooling during the afternoon, therefore enabling a mixed mode air-conditioning strategy which has been incorporated within the design.

2. Natural Ventilation:

The majority of the industrial buildings have been designed to aid natural ventilation and oriented with their long elevations facing north/south. Strategically located high and low level

louvres have been utilised to provide wind driven cross flow ventilation as a result of the pressure differential between openings.

3. Daylighting:

Early in the design phase the team initiated daylighting analysis for different glazing configurations to assist with optimising the daylight penetration; options for light shelves were explored for assessing methods to provide deeper daylight penetration. The studies justified the use of photo-electric switches for light dimming as the analysis showed sufficient daylight would be available at the perimeter zones.

4. Internal Air Quality:

The quality of the air in buildings has an impact on the health and productivity of occupants. In order to maximise the quality of the air finishes with low VOC content and engineered wood

products with low or no formaldehyde content have been specified to limit the amount of off gassing of these materials during and after their installation. High efficiency outside air filtration has been specified to capture air borne contaminants and a maintenance scheme will be put in place to clean/replace filters regularly.

5. Embodied Energy:

Embodied energy calculations were undertaken to determine the Whole of Life impact of potential construction materials across the project and recommendations made for materials with the lowest environmental impact. Light weight modular panel walls were found to have low embodied energy as well as low cost. For example, the use of pre-cast concrete on the MUR project has helped to reduce the impact of emissions from embodied energy, compared to conventional in situ concrete.



COMPLEXITY DIFFICULTY AND OPTIMISATION

THE SHEER SCALE OF THE LOGISTICS INVOLVED IN DELIVERING MUR ON A DAY-TO-DAY BASIS IS HARD TO COMPARE TO ANY OTHER PROJECT DELIVERED IN AUSTRALIA IN RECENT MEMORY.

There wasn't time to do things twice, so we built the project twice, once virtually and then once in reality, and stressed to designers and contractors that all bugs must be ironed out through digital engineering, so we could plan properly, procure early, manufacture off-site and then erect on-site


To further mitigate the impact of construction on base operations, we developed a remote Logistics Management Centre, where all deliveries to the five distinct precincts are received, marshalled, assessed and released to the correct location within the 110ha site area.

Effective logistics management was key to project's success, with the sheer scale of the project and the numbers of personnel and materials required for the project meaning that precise planning

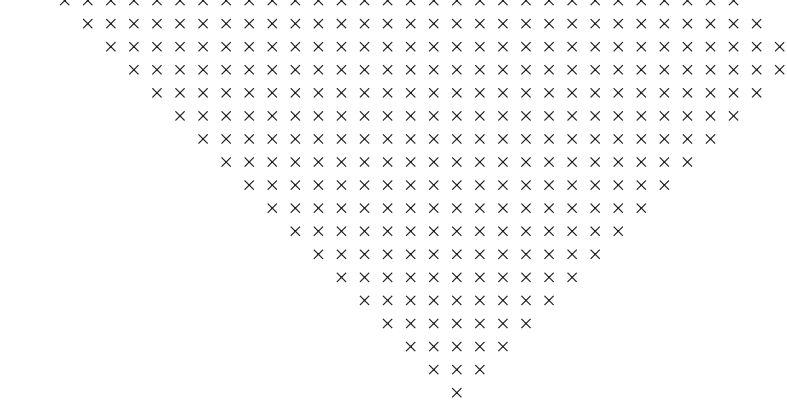
was required, the use of the logistics centre allowed our logistics team to inspect deliveries for compliance, ensure point of destination and clear security.

We understood Defence's need to keep the construction works separate from the operational base. To avoid construction vehicular traffic driving through the existing operational base (via the secondary or primary vehicle check points), we created a temporary construction access point at the Heathcote Road intersection at The Avenue. This access point and the Logistics Management Centre ensured that 95 percent of all construction works were segregated from Defence operations, which in turn ensured we met Defence's objectives of no training or operational requirements of Defence personnel being affected during the course of the works.



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- More than 9,000 workers inducted on site
 - 300 subcontractors engaged – including other Tier 1 construction companies
 - 300 separate deliveries received per day
 - Peak spend of \$1.6 million per day
 - 3,000 Military personnel continued to use the base during construction
 - 250 modular bathroom pods installed





In addition, the company’s in-house logistics management software system – Juggler – incorporates the needs of all project subcontractors and suppliers.

On the Infrastructure/Enabling Works precinct (the sixth precinct, covering the entire site), which involved the demolition and clearing of the entire site in a staged manner, up to 750,000m³ of bulk earthworks material formed the cut / fill operations, and as part of this operation, the construction of working platforms for each of the buildings were constructed.

Succeeding the earthworks was the construction of over 100km of in-ground services including the installation of pit and pipe networks for sewer and stormwater services inclusive of improvement devices, potable cold

water, non-potable cold water, fire-main and gas-main pipework.

Pit and conduit networks for low-voltage, street-lighting and communications were also installed. Further to this, 160km of cable was installed consisting of low voltage sub-mains, street-lighting, communications cabling and direct buried high-voltage cabling.

A number of earth retaining structures were also constructed including a proprietary mass-filled block wall that provided 200,000m³ of sandstone media as a plant training area for the School of Military Engineering.

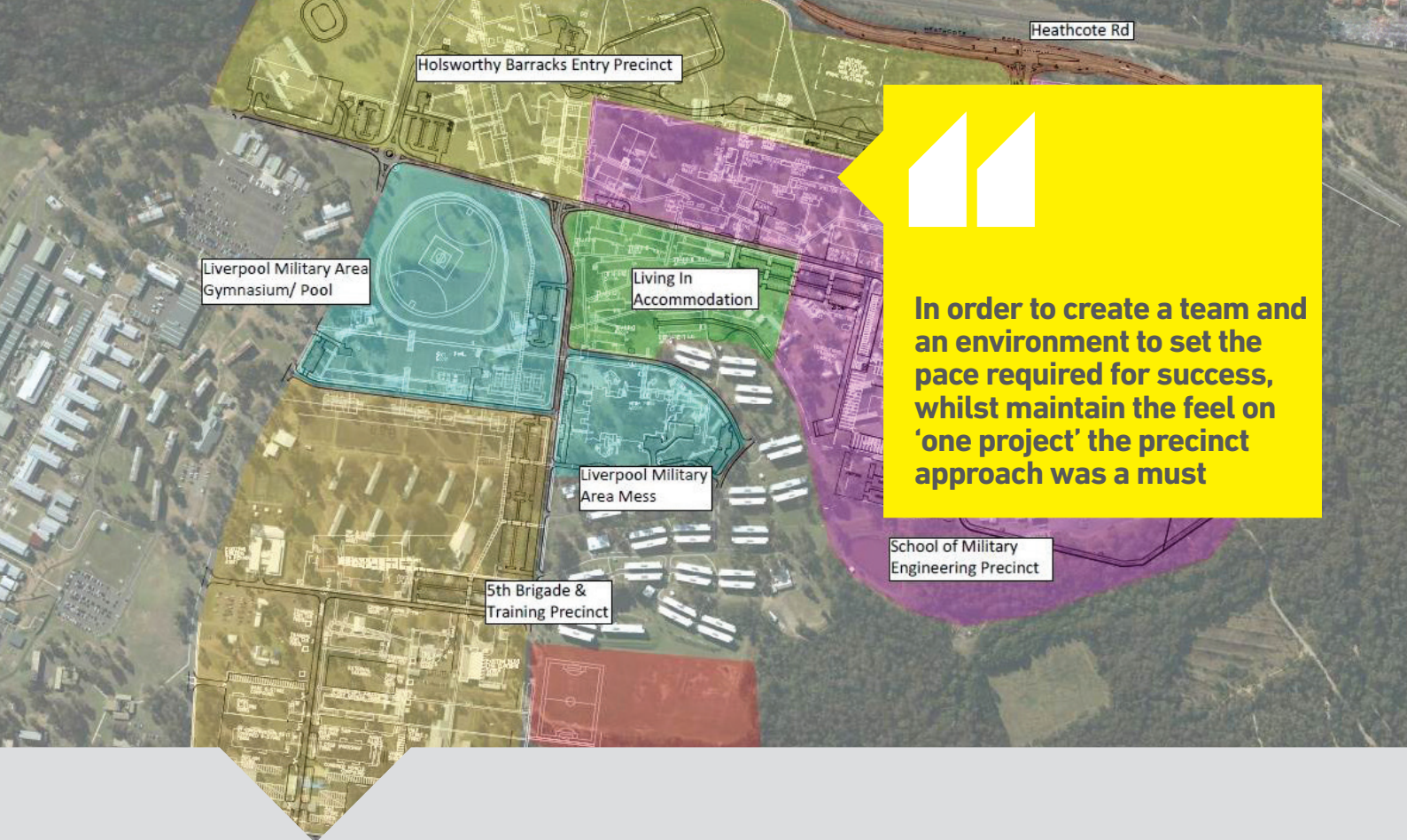
Following the installation of the in-ground infrastructure, the roads, car-parks and various other pavements were constructed comprising 20km of kerb and gutter with 100,000m² of asphalt in addition to the heavy duty concrete and block-paved areas.

As part of the finalisation the areas outside of buildings, the landscaping to the entire project was also completed by the precinct delivery team and included all concrete footpaths, access stairs, various planter areas and many different species of trees, shrubs and turf installation to the vast area of the site.



Outside of the base a new signalised entry was constructed to NSW Roads and Maritime Services standards creating a new point of access from the main exterior road.





In order to create a team and an environment to set the pace required for success, whilst maintain the feel on 'one project' the precinct approach was a must

Security

Maintaining the integrity of the security of Holsworthy Barracks was a critical requirement, whilst also ensuring minimal disruption to the operating base.

Laing O'Rourke's design team was required to provide temporary access for construction workers and deliveries and to make sure that wherever possible, the project works could be totally segregated from the main base.

The significance of carrying out major infrastructure work in a live military environment is an important consideration. The security requirements on site meant our team had to be in constant communication with the Department of Defence and work with them to adapt our approach and ensure the security of the base, and the safety of the workforce.

Staged delivery

Staging the delivery across six precincts and managing concurrent works ensured the programme schedule could be met.

The use of Digital Engineering allowed for the development of a 3D model that incorporated the building works, in-ground infrastructure services, road works and civil surface profile. The model assisted in the planning and coordination of interface works.

Detailed 4D models of typical building sections, linked to live construction

programmes, were used to inform overall construction logic and durations for each building.

The staged delivery approach allowed flexibility in planning and execution should change occur, as experienced with the asbestos finds in the ground, having the ability to transfer workforce into other areas of the project and continue at the same pace, achieving the monthly KPI's and allowing the overall project objective to be met.

The staged delivery model allowed us to keep a sharp focus on the project's critical path and ensured there were contingencies in place for any issues that arose.

Designing out complexity

The design included nine separate buildings to be designed to a fast-track program. To achieve this, our designers used Digital Engineering including BIM and standardised detailing for the buildings. This repetition enabled the design team to concentrate on only two building types – permanent and training.

To facilitate the fast-track construction program and minimise labour on-site, we adopted designs that relied heavily on off-site manufacture. These included precast concrete, structural steel, bathroom pods and prefabricated services components such as fire hose reels and stands.

Interface management

There were many important interfaces to be managed throughout the life of the project – from Military personnel continuing to use the base on a daily basis, to a childcare centre on site, Federal and State government agencies, subcontractors, to suppliers and local community groups.

As Managing Contractor, Laing O'Rourke was responsible for the cohesive management of the needs of all of these important groups and ensuring a seamless methodology between them all.

Given the six precinct approach to the delivery of the construction phase, there was a need for the careful management and integration of multiple interfaces throughout.

Management of subcontractors performing services relocation, demolition and site clearing, including remediation works, bulk and detailed earthworks; new services works including water, non-potable and potable; fire mains; electrical HV and LV; sewer; communications and other utilities; and subsequent building works.

There was also a requirement to manage the relocation of important heritage structures with a number of relevant authorities. This included European and Aboriginal artefact finds.



LEADERSHIP AND MANAGEMENT OF THE PROJECT DELIVERY

A KEY REQUIREMENT OF LAING O'ROURKE'S MANAGING CONTRACTOR ROLE WAS ENSURING PROJECT OBJECTIVES ARE DELIVERED.

As this project is the largest concentrated construction effort by Defence in Australia, Laing O'Rourke worked from the outset to understand the key project drivers and embed these within the programme delivery strategy.

Key goals included maintaining base security, completing works without disruption to Defence operations, completing works by mid-2015 to allow intermodal terminal construction, and delivering consistent value for money for the Commonwealth.

MUR was a significant and complex project, involving scores of new structures being built at Holsworthy, many with special-use requirements. These range from instructional and training facilities for the School of Military Engineering – such as a minefield clearance training area, tree felling zone, bridging yard, and a plant

training compound – to an area reserved for training explosive detection dogs. One of the largest facilities is a 58,000m² plant training area, complete with watchtowers over an eight-metre pit containing a granular fill, which is used to teach engineers how to operate earth-moving equipment.

Laing O'Rourke firmly believes that establishment of an effective and lean team framework comprising versatile and experienced members was the first step in achieving project goals. Laing O'Rourke tailored its MUR team to align to specific Managing Contractor requirements that revolve around the procurement and managing of all scope, interfaces, safety and progress on each of the hundreds of contracts.

On MUR, the early establishment of an effective team resulted in the overwhelming success of the planning

phase, with all government milestones met and exceeded. This delivered a clear, efficient and buildable solution that gained government approval through the Parliamentary Works Approval committee without issue – key to maintaining the project's tight timeframe.

It was a significant project for a number of reasons, it was the first managing contract for the company in the defence sector and was the priority for Capital Facilities Infrastructure Branch at the Department of Defence. The Department of Defence spends about AU\$1 billion per annum on capital expenditure on infrastructure and Laing O'Rourke took the opportunity, through successful delivery of MUR, to become a leader in the defence delivery sector.

Precinct approach

One of the main reasons Laing O'Rourke was originally successful in its bid to manage MUR for the Department of Defence was its approach of splitting the site into six precincts – allowing a faster delivery and a closer management focus.

There were six sub-project leaders, each with their own team. This allowed for a more manageable approach to subcontract and supply arrangements. All of the separate project delivery teams funnelled directly back into the Laing O'Rourke management team.

The subcontract workforce was diversified to spread work load among competitors whilst lowering the project's non-performance risk. This delivery model also created a level of competitive tension across the precincts which was beneficial to the overall delivery.

The School of Military Engineering

As part of the Moorebank Units Relocation, Laing O'Rourke was responsible for the relocation of the School of Military Engineering. This included the delivery of a mix of engineering instructional and learning facilities for the Department of Defence. Along with lecture theatres, classrooms, office buildings, and accommodation came some unusual training apparatus – even for a defence project.

One task often falling to these troops is bridge-building. To train soldiers in this, the Department of Defence requested a simulated landscape. Laing O'Rourke created two concrete and rock river banks with a big gap in the middle. We created a landscape that will allow the engineers to practise the tasks they will be expected to undertake.

Laing O'Rourke also delivered a 50m swimming pool for special forces water training and rehabilitation for wounded soldiers – as well as for base staff in their leisure time.


The pool is 6m deep at the deep end and is equipped with underwater cameras so special forces can monitor their training. There are also platforms so they can simulate air and water borne scenarios.

Workforce engagement

There were a number of programmes put in place to ensure the day-to-day workforce, across all subcontractors and all precincts felt engaged throughout the project.

There were regular briefings held to ensure everyone had access to the most up to date information and to ensure no silos were formed.

A buddy system was implemented for new employees, where they were paired with one of their peers to ensure a thorough induction to the project. Young workers, such as graduates



Military engineers exist to ensure that nothing stands in the way of their forces on the battlefield.

were provided a specialised one on one induction session with a senior member of the team.

The project also ensured 100 percent of personnel coming into the project completed Laing O'Rourke's behavioural safety training and a muscular skeletal awareness program.

Laing O'Rourke also provided significant resources for staff development including training in safety and environmental procedures as part of a comprehensive induction program and safety awareness strategy. A health coach was available on site for all employees and regular fitness sessions were held.

The workforce was diverse and multi-language signage was implemented across the project and translators were made available when necessary.

This proactive engagement approach and the cultivation of positive relationships with all relevant industrial relations (IR) bodies ensured that there was no lost time on site to IR issues.

Industry legacy

Of the 9,000 people employed on the project, 35 per cent were recruited from the Western Sydney suburbs within 15 kilometres of the base.

Laing O'Rourke forged relationships with local small businesses and the sheer scale of the influx of people to the local area had a positive impact on the local economy.

All of the 300 subcontractors were provided with in-depth training and guidance on how to embed Laing O'Rourke's industry leading safety programme into their organisations.

The design of the pool, gym and mess precinct at Holsworthy ensured a precinct was delivered that provided soldiers and other Defence personnel with a community and cultural hub.

Co-located with easy access to public transport and linked by cycle ways and footpaths, Laing O'Rourke delivered a distinct precinct and a unique Defence community asset.

Members of our Moorebank Units Relocation project team also joined forces with key delivery partners to deliver landscaping improvements to the Seton Recreation Hall as part of Laing O'Rourke's commitment to leave a lasting legacy in the community.

The project team also established relationships with local schools, inviting more than 180 local primary school students to visit the completed Australian Army Museum of Military Engineering.

The students came along to test out the new facility before its official opening.

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