12d International Innovation Awards

David Mares

WINNER: OVERALL

Field	Value	Category:
Name:	David Mares (on behalf of LLBJV Survey Team)	☐ **Design & Visualisation**
Position:	Survey Manager	☐ **Survey & Construction**
Company:	Lend Lease Bouygues Joint Venture	☐ **Drainage, Sewer, Utilities & Rivers**
Name Project:	NorthConnex	☐ **Customisation**
Client:	Transurban	☒ **12d Synergy**

lendlease

BOUYGUES CONSTRUCTION

A U S T R A L I A

NorthConnex

12d International Innovation Awards

Description of Project:

The NorthConnex project is a joint venture between Bouygues Construction Australia and Lend Lease to construct a nine-kilometre tunnelled motorway. When complete, the motorway will link Sydney's north to the orbital network and form part of the National Highway route.

The link between the M1 and M2 is recognized as a high-priority project by Infrastructure Australia and in the NSW Government's *State Infrastructure Strategy* and *Long Term Transport Master Plan* as important for freight traffic, for the wider connectivity within NSW, to reduce congestion, and improve traffic flow along Pennant Hills Road.

The A$3 billion project, consisting of a construction budget of A$2.65 billion, will be funded through toll charges, with a contribution from the NSW and Federal Governments of up to $405 million each.

Scheduled for completion in late 2019, the project is the largest road tunnel project ever undertaken in Australia, presenting unique challenges in the design, survey and construction and opportunities for innovative solutions to deliver a successful, cost-effective, and high-quality project within tight timeframes.

Description of problem faced / task undertaken:

Volume of Work

The tunnelling portion of this project involves, at its peak, the use of 19 road headers for tunnel excavation (a record in Australia). For a great deal of the construction period, all these machines will be in use simultaneously and operating on a 24/7 schedule, requiring a correspondingly high amount of construction survey for setout, as-built, conformance and much more. In addition to the tunnelling, other construction activity includes the northern and southern interchanges- some 3km of road- and bridge-widening. As such, the project will require the creation, capture and verification of an extraordinary amount of design, survey and construction work, under constant time, cost and quality pressures.

Data Management

Management of design and survey data has traditionally been quite poor and of an informal nature on even the largest infrastructure projects. Design information is often poorly controlled once issued, with surveyors and others having various revisions, sometimes out-of-date. Furthermore, such design information is rarely controlled or handled in a way to prevent unauthorised alteration, allowing users to modify critical design information (deliberately or accidentally). Building 3d models for setout is often left to the surveyor, with inconsistent methods, results and occasional double-handling all typically present on projects, regardless of size. Similarly, field information is usually stored on the local drive of field tablets, offering poor data security and infrequent, unreliable or totally absent backup of a project-critical resource. There exists no consolidated, authoritative source of design or survey data from which to build, create important project documentation or act as a reference source-of-truth for the project.

Field Procedures and Survey Deliverables

Due to the size and scope of the project, many surveyors will be required over the duration of the project. These surveyors will come from a wide range of backgrounds with high variation in:
- Survey coding standards (if present at all);
- File and model naming conventions;
- Data management procedures (formal or otherwise);
- Production of plots, reports and other outputs;
- Skill level and experience; and
- Minimum levels of acceptable quality.

The project, if it is to be not only successful, but innovative, must adopt new and novel ways of managing a diverse survey workforce to ensure a consistently high-quality and time-efficient output.

File Synchronization

Initially, the project used 3rd party file synchronization software. This was quick and easy to setup, but had several drawbacks:

- Sync process was manual – user had to run shortcuts on the desktop – one for each particular area;
- Sync conflicts – conflicts were sometimes encountered when several users were syncing simultaneously, requiring re-tries and delays;
- Did not scale well – the more files involved, the slower the sync process (file comparison);
- File-level synchronization – files were synchronised and replaced as an entire file, rather than just those parts that had changed, resulting in unnecessary extra network traffic and delays in the sync process;
- No access control – stored on the project network drive, all users had unrestricted access to critical project data, including the ability to inadvertently delete or modify design, survey and construction data; and
- No version control – the synchronisation relied on automated IT backups or manual snapshots at critical revisions.

All these required a need to develop and use an innovative process to ensure the integrity of the data and the success of the project.

12d Synergy

Although already well-suited to the management of data in the office and on the server, the use of 12d Synergy through the Client software was not ideal for field surveyors. Some of the issues identified included:

- Additional software – as another software package, deploying 12d Synergy would require additional training and support for all users;
- Overly complicated – most field surveyors only needed to download and upload data, they did not need to see or know of the many additional features of 12d Synergy. Hiding away such unnecessary functionality allows the surveyor to focus solely on their survey functions in the field;
- Extra steps in workflow – although tightly integrated with 12d Model, the use of 12d Synergy would involve adding extra steps to the survey workflow at a time when the processes were being streamlined to remove steps; and
- Manual process – requires the user to correctly decide which data to download, which files to upload, select the correct locations for uploads and remember to do so regularly, providing multiple points of failure and areas for mistakes.

How the problem was solved:

Centralisation of Data Storage and Processing

To simplify the management, control and issue of the large amount of survey data, the concept of a Central Data Model (CDM) was created. The Central Data Model comprises 12d Model projects for design, survey, utilities, tunnel, imagery, cadastral and survey control marks. Customisations for 12d Model, 12d Synergy, 3rd party software, help documents and training tutorial videos are also stored in the Central Data Model. Each aspect of the CDM can then be further split to allow for finer control, easier management and the future size of the projects. The CDM provides:

- A single, centralised source of truth for all data;
- A secure, managed, version-controlled and backed-up source of fieldwork and design data;
- A system for controlling and ensuring the validity of data for construction;
- A formal, consistent workflow for data management on the project;
- Allowance for growing as the amount of data increases over the project lifetime;
- A live, as-built model of the entire project, assembled as surveys are completed, rather than the traditional method of building an as-built model at the end of the project;
- Scope for automation of survey workflows;
- Consistency in 12d Model across the project; and
- Data for other survey functions, such as monitoring and guidance, and other project functions, such as geotechnical, traffic, utility relocations and program management.

Such use of a CDM is a novel and innovative solution, not previously used on a civil infrastructure project of this size in Australia.

12d Synergy Synchronization Tool

Although 12d Synergy was well-suited to management of the CDM in the office and server, it required some enhancements to better fit in with our proposed survey workflows, particularly for the users in the field. As such, the project helped develop a new extension to 12d Synergy to allow it to better fit with the typical workflows on this project (and construction projects, in general) and the use of a CDM on projects.

The Synchronisation Tool is a separate program that can be installed separately to the full 12d Synergy Client and that runs when Windows starts. The Synchronisation Tool runs in the background, communicates with the 12d Synergy server and waits for certain download or upload tasks. Such tasks can be done automatically on a schedule (certain times during the day), at a regular interval (e.g. every 30 mins) or manually. All can be done on the client computer through a single icon in the Windows system tray, greatly simplifying the interface, process and eliminating the need for extensive training in the full 12d Synergy client.

Downloads from the CDM are initiated by survey managers. In this way, end-users only need to download when the CDM has changed, cutting down on network traffic, duplicated downloads and unnecessary extra steps and tasks for surveyors. The survey manager creates a task within 12d Synergy, with a specific type, assigning it to a contact or team role (e.g. all field surveyors), and associating data from the 12d Synergy Central Data Model to the task. If the Synchronization Tool detects an assigned Sync task it proceeds to download the data without further user interaction. Emails sent automatically by 12d Synergy, describing the changes made, notify end-users that updated data is available for download.

Uploads to the CDM are done in a similar manner, but even simpler. All files from a given location on each client's computer are uploaded to a corresponding location in a 12d Synergy job. Again, this can be done on a schedule, at a regular interval or on-demand.

File downloads by each user are tracked as progress of the overall task, allowing managers to quickly and easily see who has completed the synchronization and is using the latest data.

The main benefits of the Synchronization Tool:
- Automated downloads and uploads, requiring no user interaction;
- Emails for notifications of new CDM data through standard 12d Synergy Tasks;
- Only new or modified data is downloaded/uploaded and only the file differences (not entire files), saving on limited network bandwidth and time;
- Greatly simplified process for consuming from or adding to 12d Synergy – no user training required;
- Integration – Downloads and uploads can be activated from chains, macros or other processes;
- Task Progress – managers can see who has downloaded the latest changes, who and when files were uploaded, ensuring that only current, valid data is used for construction; and
- Multiple mirrors – multiple, simultaneous and consistent copies of the CDM on individual tablets.

The 12d Synergy Synchronization Tool takes the benefits already present in 12d Synergy, but simplifies and automates workflows in a novel and innovate way for infrastructure construction projects of all sizes.

NorthConnex Upload Tasks Script

Another innovative enhancement to 12d Synergy created for the NorthConnex project was to initiate tasks on a file upload. As field survey files are uploaded, managers wanted to have a workflow for being notified of new files, along with the progress of edits, review and approvals. The script intelligently watches 12d Synergy folders for new file uploads, creating and assigning tasks and child tasks to users based on filenames, users and attributes, leveraging the standardised filenames and outputs produced from the field through customisation of 12d Model.

12d International Innovation Awards

The basic process is:

1. Watch Fieldwork folder for new files
2. For each new file, created a new task, assigning it to a survey manager based on the location of the survey
3. Look for a corresponding, post-processed fieldwork (PPFW) file:
   a. If it does not exist, then a child task is created and assigned to the original surveyor, informing them that they need to complete and submit the PPFW.
   b. If it exists, then a child task is instead created and assigned to the survey manager, to review and approve the submitted data.
4. Fieldwork tasks can then be closed as they are reviewed and approved.

The automated creation of tasks associated with submitted fieldwork files made possible via this script:

- Allows for easier management of survey tasks;
- Provides notifications and reminders of work to complete (for surveyors and managers);
- Provides useful metrics to help better manage survey resources (e.g. number of surveys done, time taken to complete surveys, surveys per project area).

Project Overview

NorthConnex

lendlease | BOUYGUES CONSTRUCTION AUSTRALIA

Who is delivering NorthConnex?
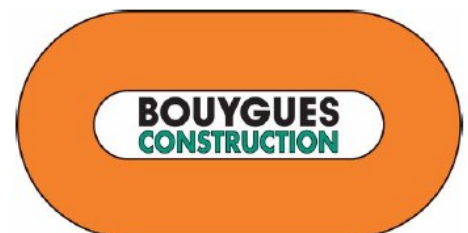
lendlease | BOUYGUES CONSTRUCTION AUSTRALIA

12d International Innovation Awards

Project - key stakeholders

lendlease

Client (Project Co.)	• Transurban, Canada Pension Plan and QIC
Contractor	• Lendlease Bouygues JV (50/50)
Designers	• Aurecon SMEC JV (50/50)

Project – Expected Project Personnel

lendlease

LLBJV Staff	• 400 +
LLB/UGL Alliance Staff	• 160+
LLBJV Direct Labour	• 500+ *300+ Tunnelling and 200+ Civil Employees*
Contractor Partners	• 800+ (including M&E)
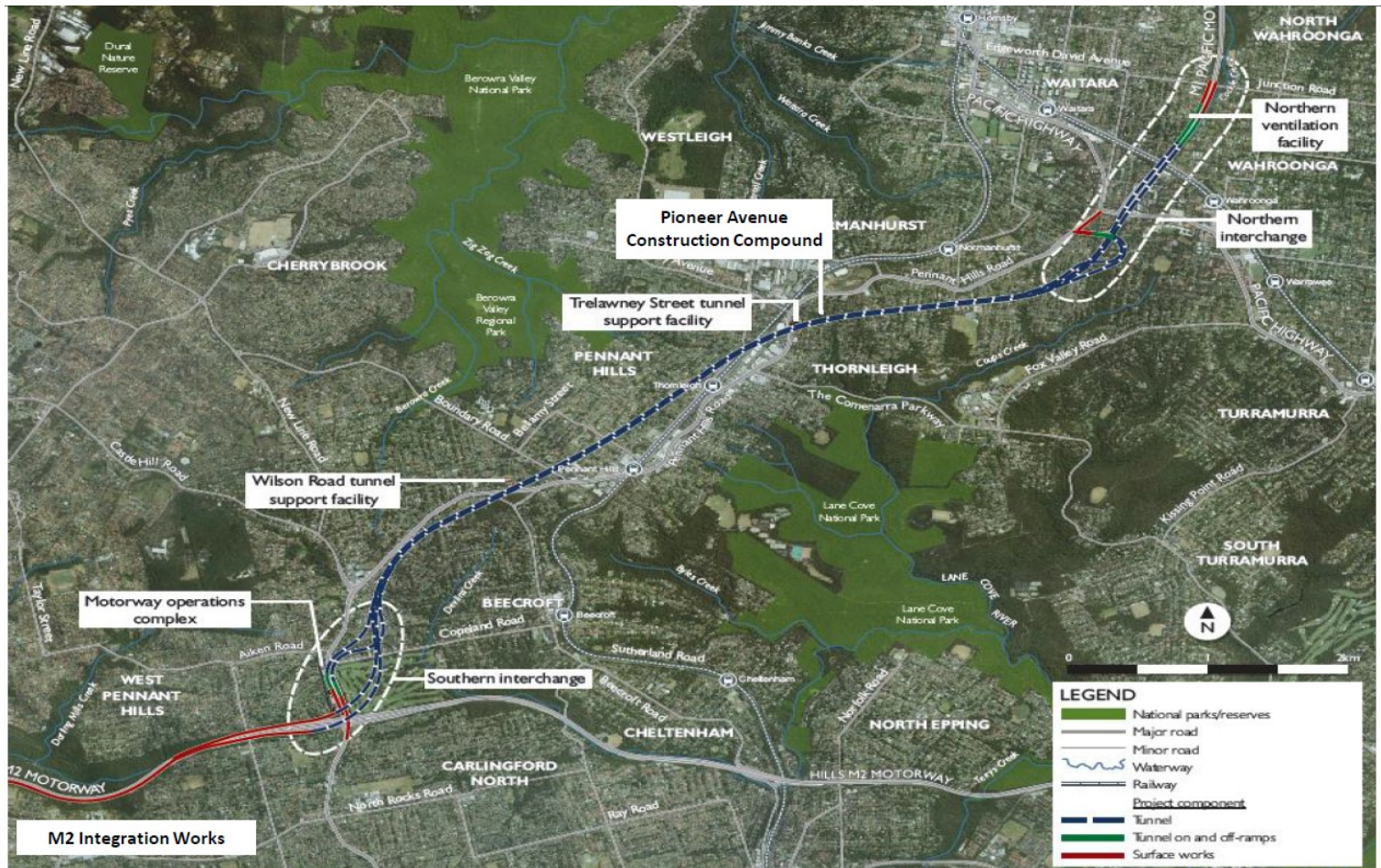
What is NorthConnex?

- NorthConnex will provide the vital link between Hills M2 Motorway and the M1 Pacific Motorway.

- Two key components – Tunnel and M2 Integration Works

- Australia's longest and deepest road tunnel – longer than the Eastern Distributor, M5 East and Cross City tunnels combined

Project scope

- Twin motorway tunnels - nine kilometres in length / two lanes plus a breakdown lane in each direction, and a speed limit of 80 km/h
- Each tunnel will be built with future capability to provide three lanes in each direction at reduced speed
- A northern interchange connecting with the M1, the Pacific Highway & Pennant Hills Road
- A southern interchange connecting with the Hills M2 Motorway and Pennant Hills Road

Project scope cont.

- A motorway control centre and ancillary buildings, southern and northern ventilation outlets and water treatment plant near the southern interchange
- Ancillary facilities for operation, such as electronic tolling facilities, ventilation facilities as well as fire and life safety systems
- Two additional smoke exhaust shafts in the event of an underground fire
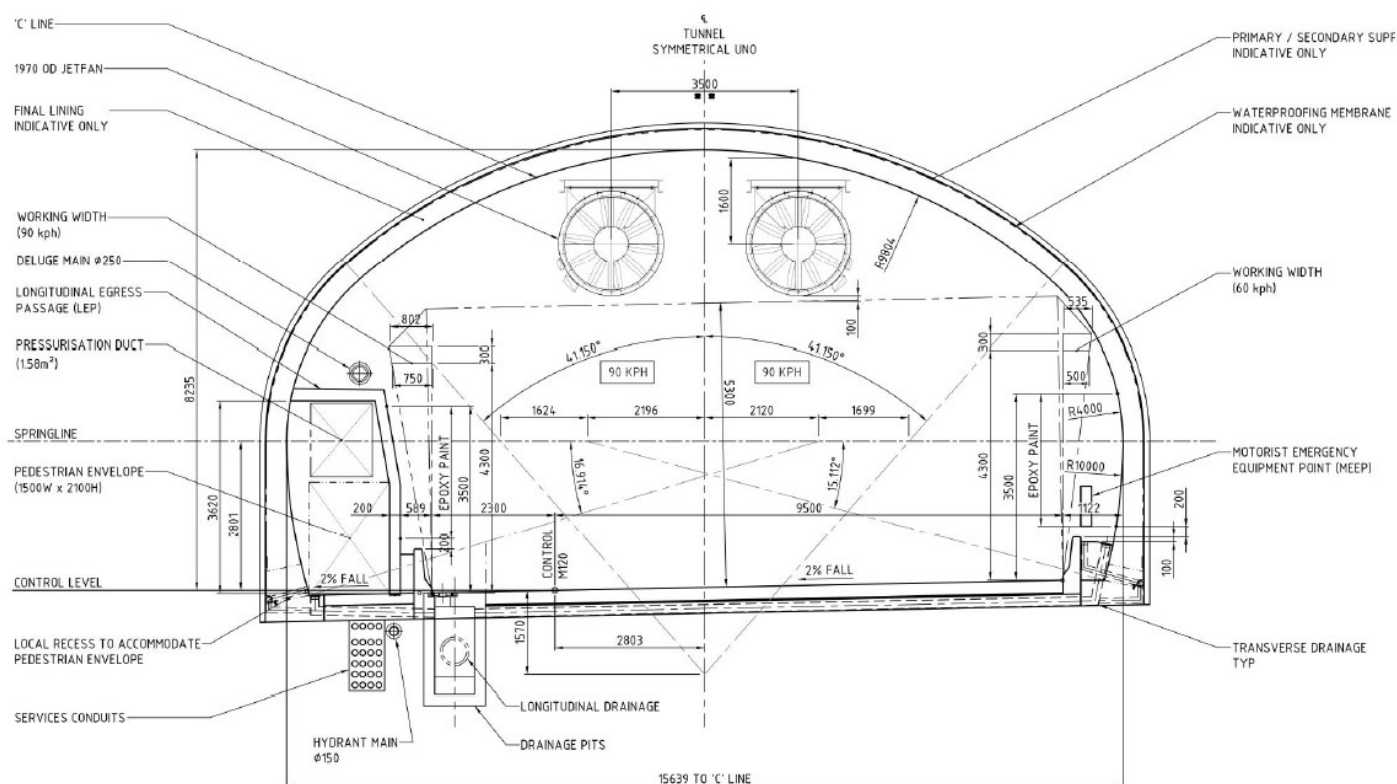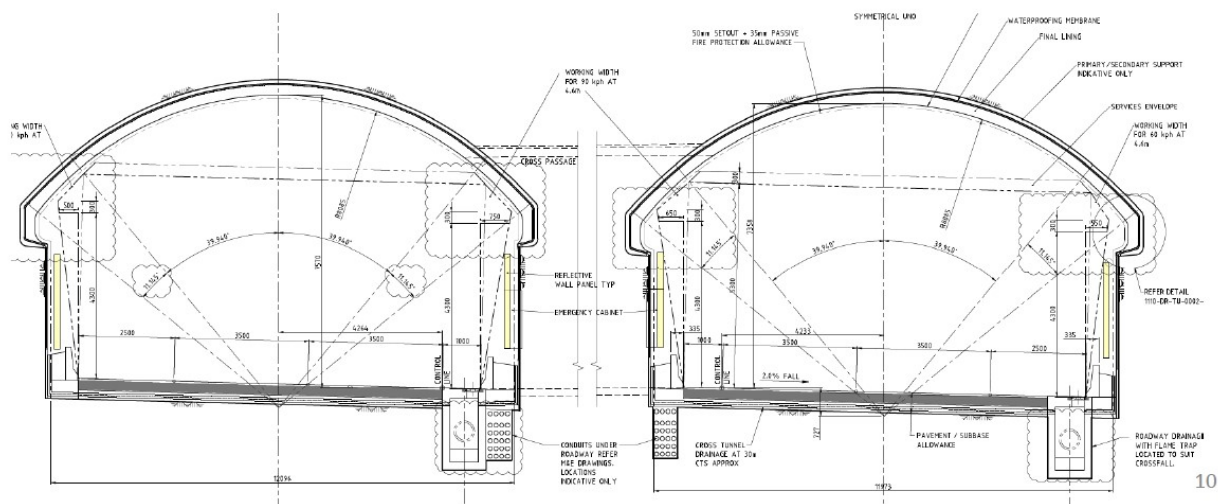- Modifications to service utilities and associated work at surface roads near the two interchanges

- 2 lane tunnel designed for future 3 lane use
- Dynamic envelope = 10.5m x 5.3m

Tunnel Concept :
- Mechanized excavation using road headers / rock boltings and shotcrete
- Drained tunnel: 1l/s/km

Tunnelling – major quantities

| Scope	Quantity
Tunnel length - mainline tunnel	16,313 m
Tunnel length - cross passage only	1,375 m
Tunnel length - on and off ramp	3,177 m
Tunnel length - Y Junctions	1,050 m
Quantity - cross passages	75 pc
Quantity - substation underground	2 pc
Quantity - low point sumps underground	1 pc
Quantity - shafts	4 pc
Excavation total	2,250,000 m3

Shaft depth

Shaft	Depth (collar to invert)
Southern Interchange	12/30m
Wilson Road	81.3m
Trelawney	56.6m
M1 Interchange	43.7m

12d International Innovation Awards

Typical Tunnel Sections
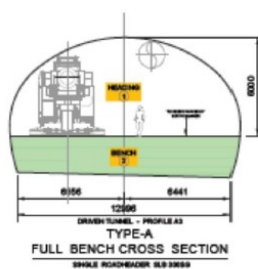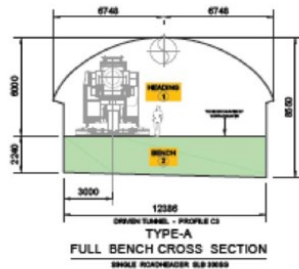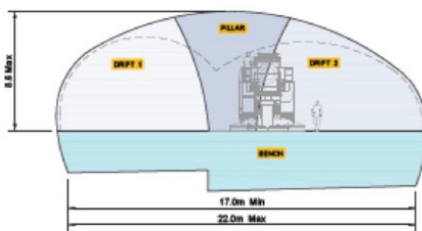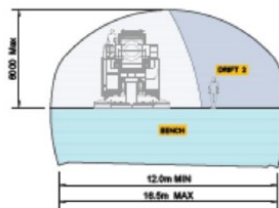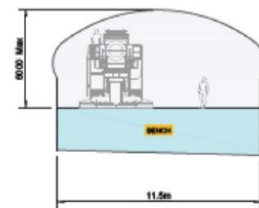
TYPE-A TUNNEL
SCALE: 1:200(A3)
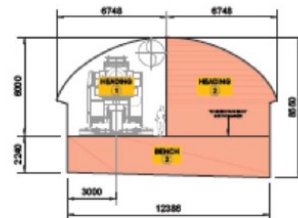
TYPE-B TUNNEL
(HIGH STRESS AREAS)
SCALE: 1:200(A3)
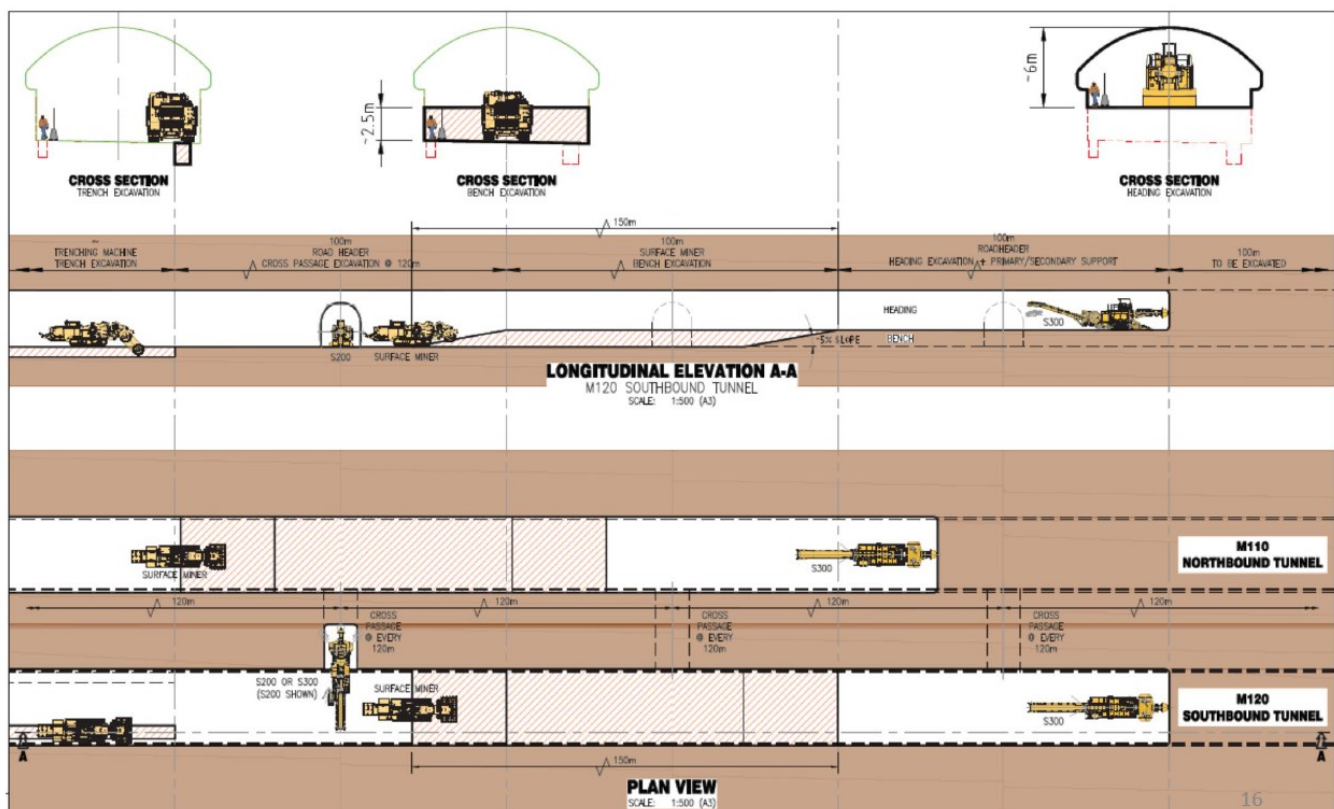
TYPE-C
SECTION A

TYPE-C
SECTION B

TYPE-C
SECTION C

TYPE-C TUNNEL
(Y-JUNCTION)

15

Different Excavation Activities in the tunnel

LONGITUDINAL ELEVATION A-A
M120 SOUTHBOUND TUNNEL
SCALE: 1:500 (A3)

M110
NORTHBOUND TUNNEL

M120
SOUTHBOUND TUNNEL

PLAN VIEW
SCALE: 1:500 (A3)

16

12d International Innovation Awards

Northern Portal & Interchange

Trelawney Street Shaft

12d International Innovation Awards

Wilson Road Shaft

lendlease

Southern Portal, Interchange & M2I

lendlease