Overview

1. Project Overview
2. Sydney Metro Product
3. Tunnel Strategy
4. Sydney Metro Northwest
5. Sydney Metro City & Southwest
More than 65 km
Two stages
31 metro railway stations
Requirements Structure

Transport for NSW Requirements
- Product Requirements
- Operational Requirements Spec (ORS)
- Planning approval conditions

“what” must be delivered to provide value

Business Requirements
- Business Requirements Spec (BRS)
  - Northern Corridor
  - Second Harbour Crossing
  - Western Extension

System Requirements Spec (SRS)
- Northern Corridor
- Second Harbour Crossing
- Western Extension

System Requirements

Contract Requirements

Civil Contact Requirements

allocated scope (key control documents)

identify “how” to deliver
Customer Experience - Requirements

- Safe and secure
- Highly legible
- Fully automated trains
- Comfortable service
- Move more people
- Fast and reliable service
- Accessible system
- Connects jobs and people
Product Requirements

• Station Locations
  • Transport Task

• Passenger Comfort
  • Accessibility
  • Experience

• Safe to build and operate
  • Fire & Life Safety
  • Maintenance
  • Constructability
Tunnel Strategy

- Configuration
  - How many tunnels?
  - Arrangement

- Geometry
  - Tunnel size – optimize
  - Tunnel alignment at stations – Shallow, straight and level

- Lining
  - Type - durable
  - Fire protection - 4 hours
  - Watertightness – drained or undrained
Tunnel Configuration – How Many?

- Twin tube
- Single tube
- Single tube-stacked
- Triple tube
Tunnel Configuration - Arrangement

Emergency Egress
- Smoke Control/Ventilation – Intermediate Service Facility
- Walkways – Side egress from train
- Cross Passages – Maximum spacing 240m
- 4.5 m wide tunnel openings
- Plant Rooms
Geometry - Tunnel Size

- For Single Deck
- Side Evacuation
- Floating Track Slab
- Overhead Wiring
- Fire Main
- Cable Trays
- Smoke Management
  - OD: 6.7m
  - ID: 6.13m
  - Clear opening: 6.0m
Sydney Groundwater

- Water contains dissolved ferrous oxide – clear liquid
- Ferrous oxide turns to ferric oxide on contact with air – brown rust particles
- Ferric oxide converts to ferric hydroxide - gelatinous precipitate
- Iron eating bacteria also thrive in this environment to add to the conversion process – very sticky gelatinous sludge
- Sulphate reducing bacteria thrive in this environment – hydrogen sulphide

Result – significant maintenance and corrosion problem.
Tunnel Lining

- Durable Concrete lining
- Steel Fibre Reinforced
- Polypropeline Fibres
- Fire Curves
- Undrained –EPDM gaskets
Stage 1 – 36km
Open first half of 2019
8 new stations; 5 upgraded
4,000 car spaces
Geology

<table>
<thead>
<tr>
<th>Rock type</th>
<th>% of tunnel</th>
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<tbody>
<tr>
<td>Hawkesbury Sandstone</td>
<td>56%</td>
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<tr>
<td>Ashfield Shale</td>
<td>26%</td>
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<tr>
<td>Transition Zone (mixed conditions)</td>
<td>18%</td>
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Geometry - Horizontal Alignment

• Norwest Station – Brookhollow Avenue
• Bridge over excavation
Geometry - Vertical Alignment

- 3.5 m rock cover to creek
- Down Tunnel – 7 m clearance to pile
Rock – Preferred Tunnel Boring Machine

Construction

CPB Contractors: John Holland & Dragados

4 x Double Shield Tunnel Boring Machines (TBMs)
- 15 km of 6.13 m diameter lined twin bore tunnel
- Almost 100,000 fibre reinforced precast concrete segments
- More than 1.5 million tonnes of rock removed
Tunnelling

More than 2.5 million tonnes of rock excavated
100% crushed rock recycled
98,184 concrete segments

Pre-cast Facility

16,290 waterproof rings
99,000 concrete segments
More than 3,600 tonnes of cement
18 months, 635,000 working hours
Segment precast facility at Bella Vista
Segments per ring - 6
Segment length 1.7 m

Weight per segment ~ 3.7 Tonne
Weight per ring ~ 22 Tonne
Total segments ~ 99,000
Total rings ~ 16,500
Sydney Metro: City & Southwest

- Chatswood to Sydenham EIS exhibition  Q2 2016
- Start major contract procurement  Q2- Q3 2016
- Sydenham to Bankstown EIS exhibition  Q4 2016
- Start construction  2017
- First TBM 2018
- Operations 2024
# Key risks and mitigation

<table>
<thead>
<tr>
<th>Risk</th>
<th>Mitigation</th>
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<tbody>
<tr>
<td><strong>Sydney Harbour Crossing</strong></td>
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</table>
| Harbour Crossing rock depth                                          | • Geophysical investigations to be undertaken in December 2014  
• Geotechnical borehole investigations to be undertaken in early 2015 |
| Interface with existing buildings, basements & tunnels               | • Investigation / surveys of adjacent properties  
• Existing buildings and structures assessment |
| Pitt Street Station transition cavern & Cross City Tunnel            | • Alternative design options under consideration  
• Alignment over existing Cross City Tunnel transfer slab, with design & engineering investigations to confirm load design |
| Central Station constructability                                     | • Investigations to determine construction impacts from SRT in parallel to other Central Station works  
• Design options considering minimising impacts |
| Central Station scope                                                | • Consultation with Central Blueprint team  
• Constructability and pedestrian modelling investigations to confirm scope requirements for SRT (East/West concourse) |
| Martin Place                                                        | • Alternative design options / property under development |
| CBD construction site access constraints                              | • Property acquisition sufficient for station construction requirements  
• Constructability investigations to minimise impacts to adjacent sites and utilisation of sites outside of the CBD (and North Sydney) |
| ‘Construction fatigue’ experienced in the CBD and other high impact areas forces changes to methodology and staging. | • Active stakeholder engagement, including RMS and City of Sydney  
• Approach to constructability to minimise impacts in highly congested areas  
• Assessment of other concurrent works to identify conflicts, interfaces, overlaps |
Desk Study
Ground Investigation - Geophysical

- Sonar Scan
- Seismic Reflection
- Seismic Refraction
- Magnetometer Scan
Investigating The Harbour

Planned
- HQ coring + SPT
- In-situ stress testing
- Water pressure testing
- Downhole imaging

Additional
- Denison Sediment sampling
- CPT
- Cross-hole tomography
- Geomechanical testing
- Sedimentological analysis and testing
- Resistivity
Harbour Crossing - Alignment

Option 1 – Rock TBM
Option 2 – Soft ground TBM
Option 3 – Shallow IMT

Barangaroo 24m bgl
Vic Cross 28m bgl

Barangaroo 24m bgl
Vic Cross 30m bgl

Barangaroo 41m bgl
Vic Cross 42m bgl

Figure 4.8 Sydney Harbour crossing vertical alignment options considered

Extract from State Significant Infrastructure Application Report
Harbour Investigation - the findings

- **Corresponding fault zone in Cross hole tomography highlighting the low angle fault zone**

- **Hawkesbury Sandstone with low angle fault zone**

- **Unit 1**: 39,430Ka
- **Unit 2**: 22,600Ka
- **Unit 3**: 50,100Ka

- **Cross section sketch** showing the geological features and chainage (0x0)
Tunnelling Strategy

TBM selection
- Mixed Ground
- Soft Ground
Interventions
Geotechnical Processes
- Ground Treatment
- Ground Freezing
Access shaft at Blues Point
Harbour – Tunnel Boring Machines

Slurry Machine

Earth Pressure Balance Machine
Harbour – Tunnel Boring Machines

Convertible Earth Pressure Balance Machine

Hybrid Tunnel Boring Machine
Harbour – Preferred Tunnel Boring Machine

1. Cutting wheel
2. Air bubble
3. Bentonite suspension
4. Drive unit
5. Stone crusher
6. Push cylinder
7. Air lock
8. Steer cylinder/shield tail
9. Erector
10. Segment conveyor
11. Slurry pump
12. Segment crane
13. Main electric panel
14. Cable reeling drum
15. Discharge line
16. Feed line
Harbour – Ground Treatment

KEY
- Tunnel alignment
- Grout zone

MILLERS POINT
grout barge
spoil barge
Sediment
Hawkesbury sandstone
BLUES POINT
Hawkesbury sandstone
City Alignment
Underground constraints

Existing rail line
Construction site
(note: temporary closures of Martin Place required during construction)

Not to scale
Development opportunities

Over station development (by others post TSE)

'Jump' slab level

Above ground station structure

Below ground station structure
Martin Place Interchange
Binocular Platform Cavern
Single Platform Cavern
Thank you