

## **M&E Technology | QS-6B | Delivery Methodology | Fit-out Methodology for the M&E and Technology Installations**

3. Your fit-out methodology shall include the following information as a minimum:

- 3.1. the fit-out and installation stages and activities for the M&E and technology installations, including:
  - 3.1.1 a description of the installation sequencing in relation to other works;
  - 3.1.2 proposals for offsite activities;
- 3.2. how the fit-out and installation stages and activities will be de-risked.



### 3. Fit-out Methodology

M&E installation sequence and techniques will be strictly aligned with the tunnel arrangement and civil work construction sequence.

The Work Procedures will be developed with appointed subcontractors, but some general criteria and planning assumptions are explained here.

A key element of BADGER's design solution is the use of the under-deck space for equipment installation and maintenance access. This creates a new, separate space that pose new challenges in design and construction but offers big opportunities for installation and operations.

We have outlined in this document the challenges and opportunities arising from the proposed design, noting that these may change during the delivery stage according to the Work progress, input from subcontractors and the requirements of third parties.

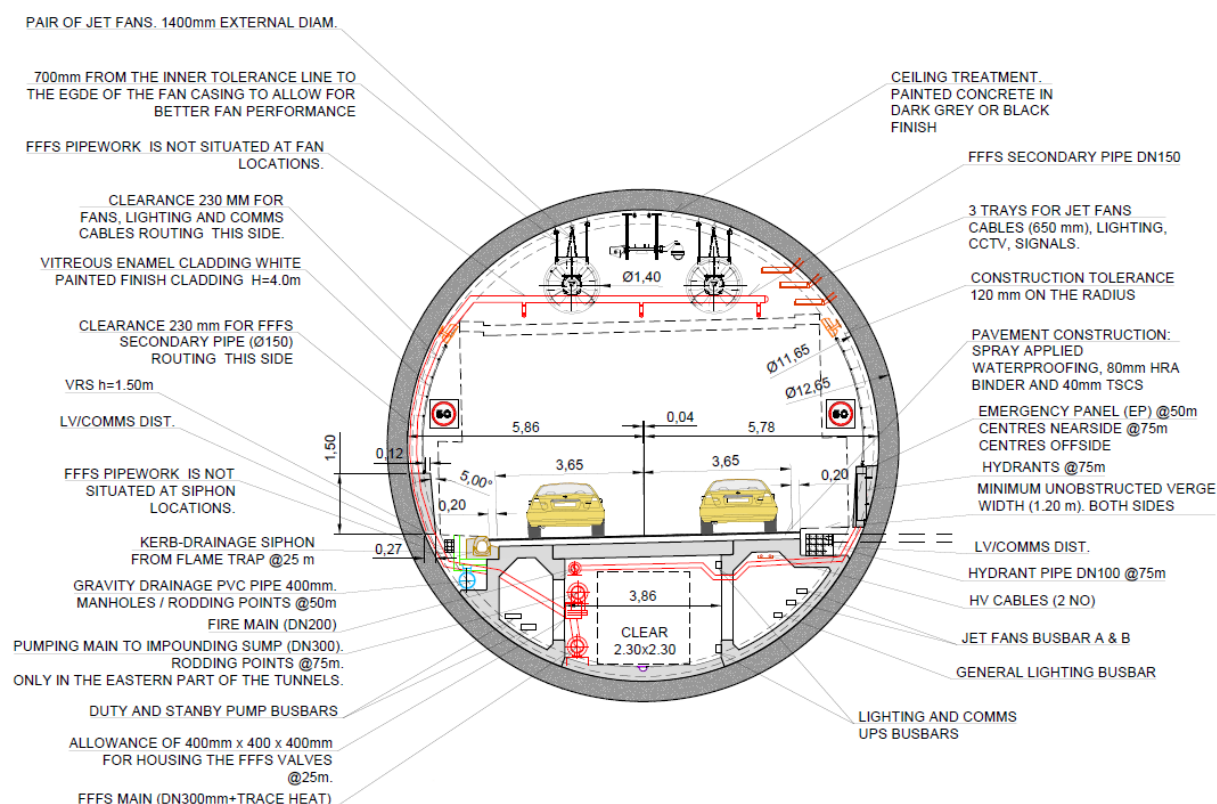


Figure 1: tunnel Cross Section showing MEP services

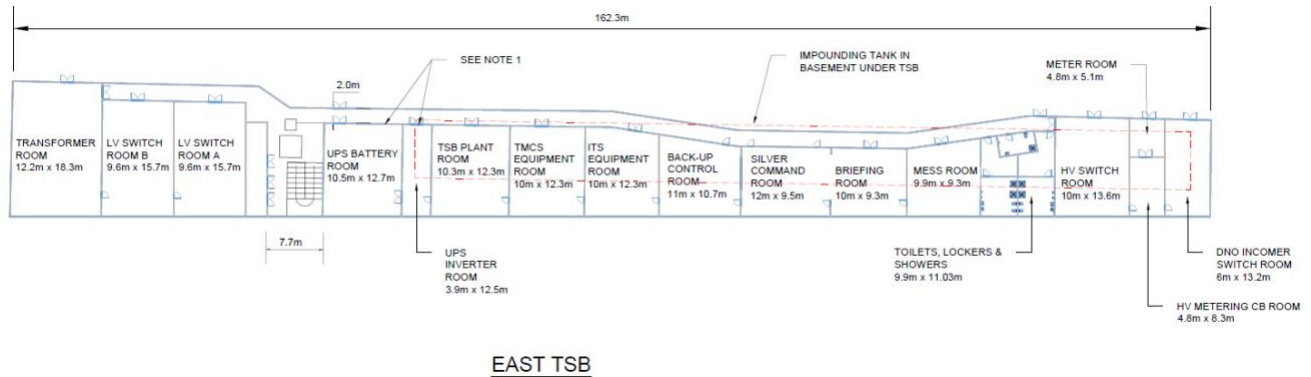


Figure 2: Tunnel Service Building plan view (extract from QS6A drawings)

### 3.1. Stages and activities for the M&E and technology installations

BADGER's lead MEP Contractor will coordinate the M&E packages for supply installation and commissioning.

Installation activities will start when work zones are handed over from the Civil team to the M&E teams. In the following paragraphs, we further explain the M&E delivery phases and key interfaces.

The detailed M&E sequence will be developed in conjunction with the third parties and subcontractors.

#### Design:

Subcontractors will be selected and engaged at an early stage. Equipment selection, datasheets, installation and maintenance procedures will be incorporated in the design. For specialist disciplines (e.g., FFFS and lighting), the subcontractor's inputs to the design will be particularly important.

#### Tunnel Fit-out:

For each discipline, once the work zone has been cleaned and handed over by civil works, the following phases of M&E work will be undertaken (shown in Figure 3 and Figure 4)

- 1<sup>st</sup> fix: includes the installation of pipe bracketry, cable containment, hangers and supports, pipework, valves and cable pulling.
- 2<sup>nd</sup> fix: includes the installation of the most robust equipment, including Jet Fans, FFFS valves and pipes, panel boards and their connection.
- A final fix is considered for sensitive devices such as light fixtures, TMCS sensors, VMS and CCTV cameras. This has not been explicitly shown in the programme, but after completion of civil works e.g., waterproofing and asphalt, this final fix will take place.

Sequencing of these activities has been shown in Figure 3 and Figure 4 for both the Tunnel bores and the TSBs. They also show relationships with other disciplines, which are further detailed in section 3.1.1.

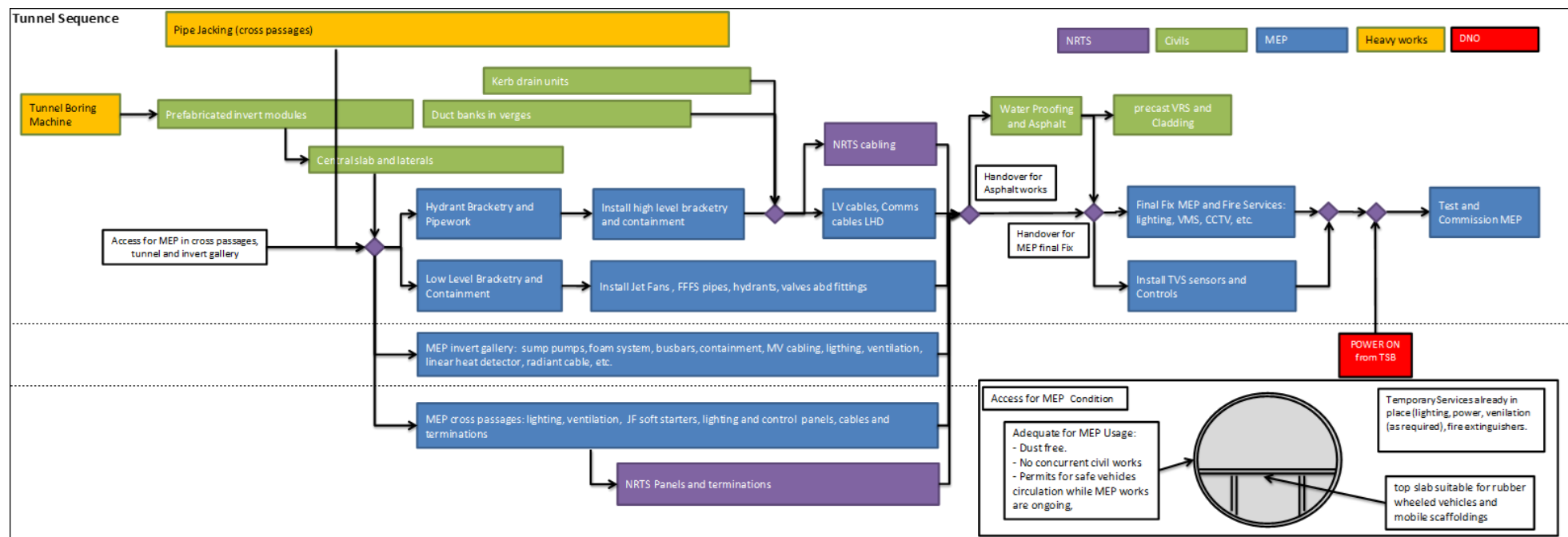


Figure 3: M&E fit-out diagram

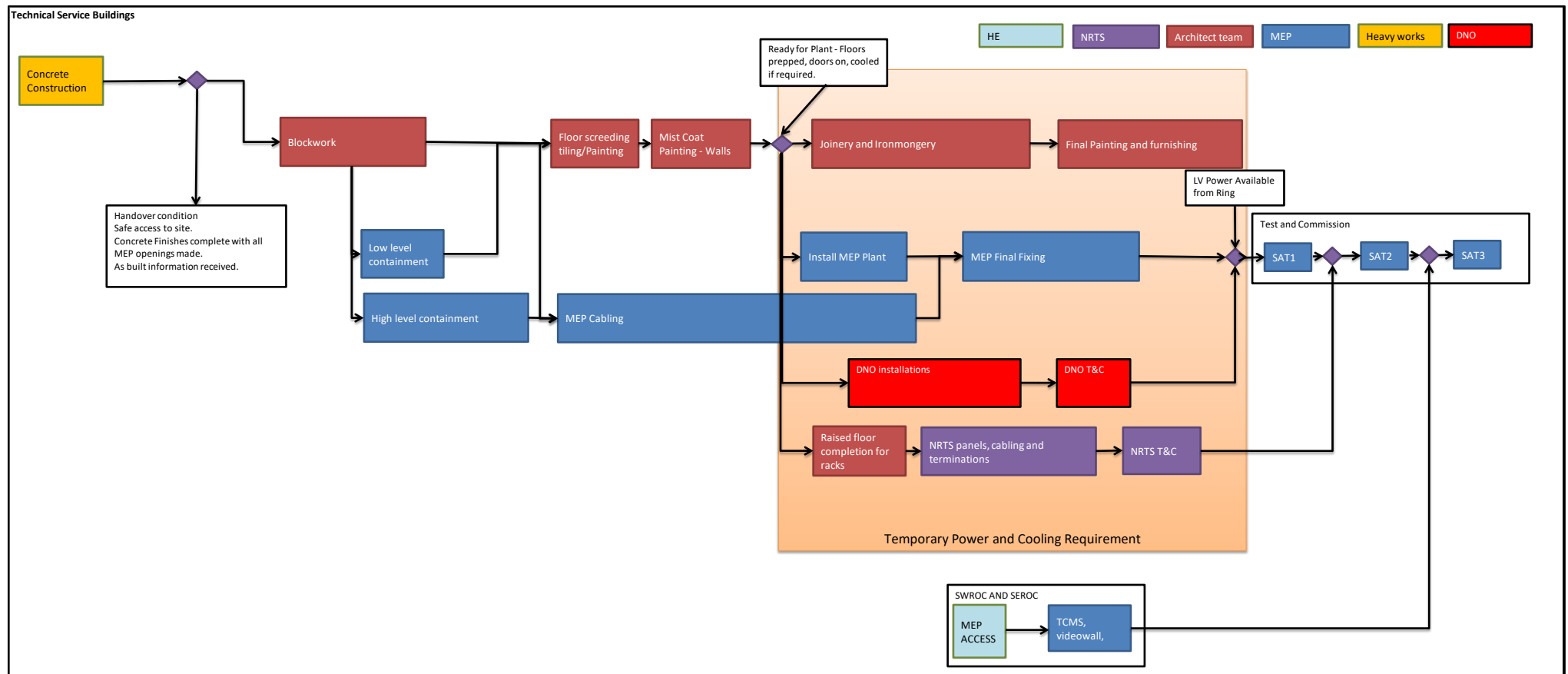


Figure 4: M&E fit-out diagram- TSB



Similar to the Tunnel bore and given the overall length of the TSB (160m), it is expected that M&E activities will start in selected critical rooms, in advance of completion of builder work. BADGER will give priority to functional rooms, e.g., those reserved for DNO and NRTS, to allow installation to start in these critical areas.

The detailed sequence of each discipline, and the relationship between them, will be detailed at a later stage, as all parties need to provide specific inputs and requirements at the start of installation (e.g., environmental conditions and power supplies).

#### **Third parties:**

Third parties are required to complete parts of the Works. Key interfaces are:

- NRTS for telecommunications network
- DNO for HV power supply
- ROCs for civil and architectural works.

The Third Parties will be involved as 'other subcontractors' in the detailed installation sequence, and during all site activities.

NRTS panels and terminations will be completed within the cross passages. In the programme it has been assumed that these will be completed once necessary provisions are in place, including racks and cable containment. Cabling will progress as soon as racks are available.

DNO will lead the provision of the power connection to the tunnel. Its activities will mainly be in the tunnel service building. DNO will be given priority for completion of their reserved area so that their activities can start as early as possible.

Given the criticality of third-party interfaces, they are developed in section 3.2 regarding risk mitigation.

### **3.1.1. Installation sequencing in relation to other works**

Ideally the M&E installation will start once all the construction has been completed. However, given the available schedule, there will be overlap with civil construction and the M&E installation activities. They will be coordinated, to meet the completion date required. The coordination will ensure that Quality and Safety is not compromised and that the number of operatives working in a given area is kept to a minimum.

To mitigate critical path activities, BADGER will start M&E activities in advance of civil construction completion – whilst maintaining the focus on safety via implementing safe methods of work and approved methods and procedures.

BADGER will plan in great detail, the sequential activities where M&E fit-out follows civil works. This is particularly important for the tunnel and cross passage excavation and invert gallery erection.

With reference to Figure 1, the following "heavy works" are shown:

- Tunnel boring
- Pipe jacking

The progress of the above mentioned works is the driver for the beginning of the following civil activities which are required for the M&E site access:

- The completion of the prefabricated gallery invert units
- Road slab and lateral element completion (after Cross Passage excavation)
- Laying and concreting of ducts in verges and laying drain units.

Waterproofing and Asphalt will follow completion of road slab installation and cladding will be completed after the FFFS pipes are installed.

This sequence is included in the overall programme to accommodate the area requirements and activity segregation for each phase.



The sequence is illustrated in the following diagrams, which also show how the site traffic will be relocated once the second bore has been completed. A second access will also be available for the East Bound (EB) tunnel:

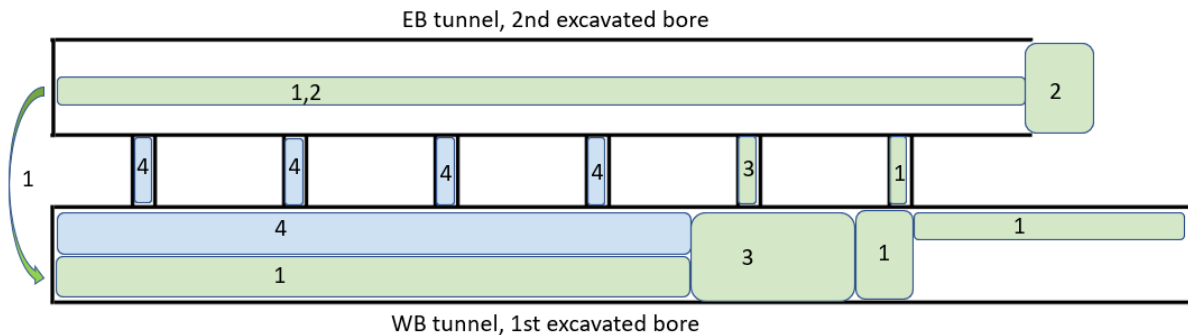


Figure 5: Stage 1 – the M&E activities progressively advance along WB (general tunnel areas plant view). Area 1: reserved for pipe jacking logistics, Area 2: reserved for TBM, Area 3: reserved for cross passages (CP) civil construction, Area 4: available for M&E.

### First Stage:

- The 1<sup>st</sup> TBM drive is completed, 2<sup>nd</sup> drive, and CPs execution are in progress.
- The lateral invert elements will be installed during the excavation of first TBM drive (West-bound tunnel, WB) as described in QS3B, but the road slabs and lateral units at the CPs will be installed later to avoid clashes with the pipe jacking (PJ) machine (Area 1 in Figure 5).
- Completion of the CPs, precast invert units, road slab, lateral units and construction of duct banks and drain units in WB tunnel (Area 3 in Figure 5) are carried out in coordination with the advancement of CPs. This activity is driven by the excavation of the second bore (EB) where the PJ head is received, disassembled, transported out of the tunnel (at the western portal) and relaunched at the next CP location (the area used by this traffic is labelled as 1 in Figure 5 and Figure 6). The M&E activities will progressively advance in the WB tunnel as civil works are completed. A safe distance will be maintained where, as a general rule, approximately 500m of separation will be in place. M&E installation will start when 6 No CPs are complete to ensure that it is carried out in a dust free environment (the area where M&E installation is in progress is labelled as 4 in Figure 5).
- M&E Activities will be progressing both in the invert gallery and at road level. The second being segregated from other traffic with temporary road barriers (Figure 6). The areas reserved for M&E installations are those closer to the Cross Passages, where most of the equipment and materials will be installed. There will still be some equipment to be installed in the opposite side, which will be installed once the civil site traffic has been re-routed during the next stage (second stage below). In area 1 of Figure 6, site traffic and material handling only are expected. The sequence diagram in Figure 3 indicates some civil finishing and a final M&E fix for which a detailed sequence, if required, will be programmed in the delivery phase.



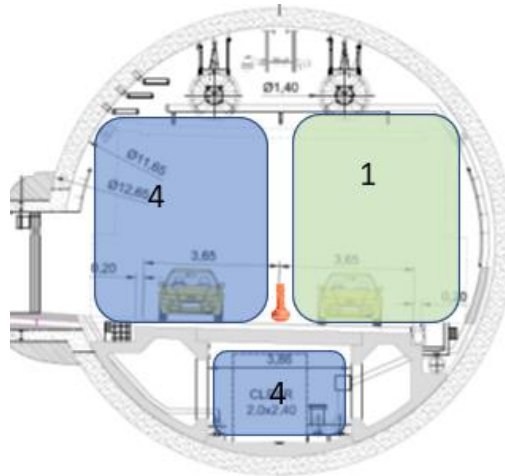


Figure 6: Tunnel bore cross section. Area 1: civil traffic, Area 4: MEP installations

## Second Stage:

- Both TBM drives are completed, CPs and road slab are progressing.
- With the completion of the 2<sup>nd</sup> drive it will be possible to provide an alternative access to the second bore for material handling, by the East portal (Area 1 in Figure 7), in particular:
  - The TBM shield is moved forward by 60m immediately after the excavation is finished.
  - TBM services are dismantled along the EB tunnel, and the gantries will be removed progressively from the Eastern approach (area 2 in Figure 7).
  - Pipe Jacking material supply and relaunching will be done via the Eastern portal (area 1 in Figure 7).
- This will then allow progression of civil works along the EB (Area 3 in the EB).
- M&E installation sequence will progress together with road completion starting from western approach, in a similar way to the WB tunnel. The same time/space separation that was previously described for Stage 1 will apply. Two months are programmed for remaining civil works before M&E installations start.
- The WB tunnel will also benefit from this sequence and area configuration as interferences will be significantly reduced (Area 4 in WB tunnel).

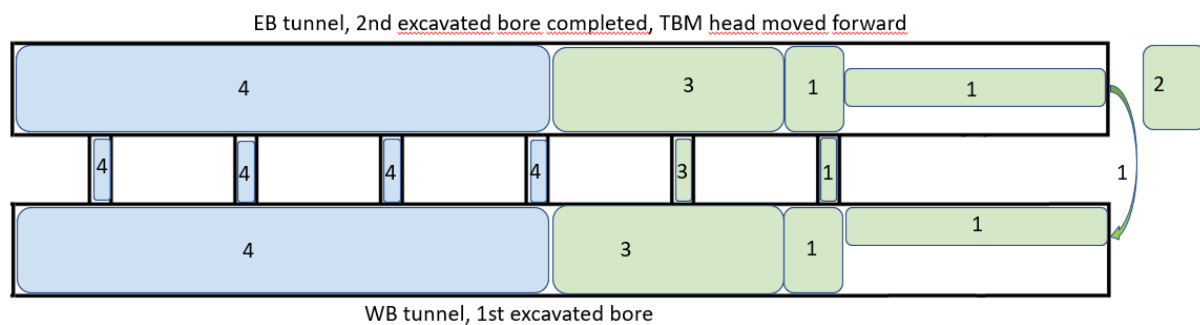


Figure 7: Stage 2 – at this stage the M&E activities progressively advance along EB tunnel from the West Side because the TBM has finished, and PJ U-turn is relocated on the East Side.

In both cases, the following conditions are to be met before the M&E teams can access the area and start the fit-out:

- The road slab shall be completed and suitable for rubber wheeled vehicles. The tunnel traffic will be re-routed to the final road level as required (see Figure 6), The slab shall then be able to withstand the loads and be safe for driving.
- Where necessary, temporary services shall be used to guarantee a safe working environment. Lights, ventilation, communications, and drainage will be required until the permanent ones have been installed.





- There will be no dust and dirt sources, ensuring the health and safety of the people and the care of the equipment and validity of the warranties.
- During the M&E installation there will be no concurrent civil works in the same section. These will be completed up to a certain stage and other finishes will be completed in sequence to M&E 1<sup>st</sup> and 2<sup>nd</sup> fix. In the invert gallery no additional civil activities are foreseen, and at road level the duct banks and drain completion will be completed. Asphalt layers and cladding will be completed after the 1<sup>st</sup> and 2<sup>nd</sup> M&E fix.
- The final fix will be performed only at the end of the major works in the tunnel, to minimise the risk to damage sensitive permanent M&E equipment.
- A permits procedure will be implemented for the safe circulation of vehicles while the MEP works are ongoing. The progress of activities will be different along the tunnel. The sequence has been organised to avoid unnecessary material handling along the tunnel. If some re-work is required or if there are pending installations dedicated permits to transit along handed over areas will be required.

### 3.1.2. Offsite activities

The most important tasks foreseen outside the construction area are the SW-ROC and SE-ROC fit-out. At this stage no information is available for these buildings, such as access dates, layout, interfaces, and other activities. For the purpose of the Tender, assumptions have been made in our programme.

In the case of the SE-ROC, it is expected that during the design period a completion programme, building drawings, space requirements (and others to be detailed) will be made available in order to complete the design in close dialogue with the Project Manager. In the case of the SW-ROC, which is currently operational, it is expected that, in addition to the above, a specific permission protocol and close coordination with the operation personnel will be required in order to minimise disruptions.

Other activities may be possible outside the construction site in order to minimise the area required and in anticipation of some progress before the areas are handed over. This will reduce the number of activities and operatives in the tunnel and improve safety. We will prefabricate and preassemble offsite as much as possible.

## 3.2. Fit-out and installation stages and activities De-risk

Within all the MEP related risks, some major risks require special attention as they may impact project delivery. These include:

### Interfaces and third parties:

There will be several interfaces to be managed. Risk mitigation will be achieved by detailed and specific coordination actions. An integration system shall be put in place in the early phases, to ensure that all parties and stakeholders are properly involved and that there are no gaps in the overall scope and design. Risks have the potential to result in cost and time impacts, with design delays, reworks, supply and installation delays and poor site coordination.

Badger's will implement mitigation actions;

- All parties will be appointed and mobilised at an early stage. This will ensure that design information will be made available to all parties from the earliest stage in the design process. This will include a shared document control system.
- Responsibilities, battery limits, work procedures and access requirements are defined and agreed. Responsibility and supply matrices will be prepared to detail all interfaces. This will minimise the risk of overlapping works and prevent gaps in the overall Scope of Works.



- Person in Charge shall be appointed by all of the involved parties and communication protocols will be defined at the initial stage. An Interface Working Group will be created so that all the information can be shared, agreed and controlled properly.
- At the earliest possible date, a structure of weekly meetings will be put in place to resolve any issues relating to design, coordination with other disciplines and third parties, material delivery, Quality and Health and Safety.
- Design teams will be mobilised at an early stage to be able to accommodate the design of other disciplines, especially for space proofing, structural opening, sleeves and cableways definition, as these need to be implemented in the concrete and civil works design well in advance of the MEP design.
- Site works will be properly sequenced and coordinated. All parties will be involved, providing necessary inputs and contribution as necessary.
- Priority will be given to the technical rooms in the tunnel service building in order to mitigate risks of delaying third party activities.

The results of all the above will be incorporated in an Interface Control Document (ICD) along with requirements, the responsibility matrix, IO's, the cause and effect matrix and handover condition. Protocols and procedures will be set up and agreed with the other parties, in order to allow the proper information distribution (methods and instruments), avoiding abortive design and construction works and anticipating coordination challenges, especially during the SAT 3 commissioning phase.

#### **Material supplies:**

The availability of materials at site is critical to the project success so special efforts will be made to start the procurement as soon as possible to minimise the risk of delivery delays which might jeopardize the project. The materials and plant deliveries will not be programmed too early to avoid exposure to degradation and damage, and space problems at the site storage facilities.

The current changing international commerce and logistics situation (such as those resulting from "Brexit"), and global context (COVID-19) has shown the vulnerability of international projects to unpredictable supply chain disruptions.

Two main actions have been considered to minimise both the probabilities and consequences:

- Where possible, preference will be given to local suppliers. This will minimise the vulnerability to the international context, even accepting that low-tier supplies may be affected. This will also provide a reduction in local storage capacity requirements.
- The selection of highly qualified and experienced subcontractors will improve the capacity to coordinate all delivery phases, differentiate the material supplies where necessary (e.g., bulk materials and cables) and develop alternative supply strategies.
- Subcontractor experience will also increase capacity to coordinate site activities, reducing overall disruption risks.