WestConnex M4 East

CPB CONTRACTORS | SAMSUNG C&T | John Holland

Tunnel Ventilation, Incident Response and Traffic Management System Integration Protocol

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1 Introduction

1.1 Purpose

The purpose of this "Tunnel Ventilation, Incident Response and Traffic Management Systems Integration Protocol" (the Protocol), as required under Conditions of Approval B7 and B3, is to demonstrate that the systems provided will operate together to ensure that the objectives defined in Part E of the Infrastructure Approval for the WestConnex M4 East are achieved.

1.2 Executive Summary

The objective of this document is to demonstrate that the systems provided for the WestConnex M4 East project would operate together to ensure that the conditions of this approval are met. Maintaining these air quality limits will additionally ensure that the limits specified in condition E9 and E14 are not exceeded.

In order to achieve this, the following approach has been adopted:

- The ventilation system has the ability to control the tunnel ventilation depending on air-quality measurements in order to comply with the minimum air-quality limits under Normal Operation
- The traffic management system is able to implement the specific traffic control practices to achieve specified objectives
- The ventilation system alone is capable of meeting majority of incident conditions and the traffic management system assists by controlling the amount of produced pollution which impacts the required ventilation capacity to maintain air quality limits;
- Operational philosophy has utilised an integrated approach for the control of ventilation and traffic management. This is to avoid congestion even though the tunnel ventilation has the capacity to control air quality within nominated limits under traffic conditions as specified in the Scope of Works and Technical Criteria (SWTC);
- Incident Response Plan developed for operation of the tunnel integrates all systems to provide optimum response under any incident condition;
- All systems will be thoroughly tested inclusive of integrated systems commissioning, in accordance with this Protocol, prior to opening the motorway to traffic.

The focus of this document is on the WestConnex M4 East project as a stand-alone tunnel and similar documentation shall be developed once integrated with other WestConnex project stages.

1.3 Definitions and Abbreviations

Table 1: Abbreviations used within this Report

Abbreviation	Description
APID	All Purpose Incident Detection Algorithm
AVIDS	Automatic Video Incident Detection System
CCTV	Closed Circuit Television
CMS	Changeable Message Sign
CSJ	CPB Samsung John Holland Joint Venture, also known as the Construction Contractor
F&LS	Fire and Life Safety
FAT	Factory Acceptance Testing
FHEOM	Fulton Hogan Egis O&M Pty Ltd, also known as the O&M Contractor
FRNSW	Fire & Rescue NSW
IC	Independent Certifier
IMP	Incident Management Procedure
IRP	Incident Response Plan

Abbreviation	Description
ISLUS	Integrated Speed and Lane Use Sign
ITC	Inspection and Test Check-List
ITP	Inspection and Test Plans
M&E	Mechanical and Electrical
M4E	M4 East
MCC	Motorway Control Centre
McMaster	McMaster Incident Detection Algorithm
MNCS	Motorway Network Communications System
O&M	Operations & Maintenance
O&M Contractor	Fulton Hogan Egis O&M Pty Ltd
OMCS	Operations Management and Control System (includes TMCS & PMCS)
PLC	Programmable Logic Controller
PMCS	Plant Management and Control System
PRVF	Parramatta Road Ventilation Facility
RMS	Roads and Maritime Services
SMC	Sydney Motorways Corporation
SWTC	Scope of Works and Technical Criteria
TCP	Traffic Control Plan
The Protocol	Tunnel Ventilation, Incident Response and Traffic Management Systems Integration Protocol
TMC	Transport Management Centre
TMCS	Traffic Management and Control System – the traffic control software within the OMCS responsible for all traffic control and related control and monitoring
Traffic Management	Traffic management is the application of specific traffic control practices, within a defined policy framework, over a length of road or an area, to achieve specified objectives (Austroads, 2015)
UPS	Uninterruptible Power Supply
URVF	Underwood Road Ventilation Facility

2 Consultation on this Protocol

Transport Management Centre (TMC) have been directly involved throughout the development of this Protocol in accordance with the requirements of the WestConnex M4 East Infrastructure Approval.

The process for development and review for this Protocol was:

1. The Construction Contractor developed:
    a. The Traffic Management and Control System (TMCS) in accordance with the SWTC and WestConnex M4 East Infrastructure Approval.
    b. The Tunnel Ventilation Design in accordance with the SWTC and WestConnex M4 East Infrastructure Approval.
2. The Construction Contractor and the O&M Contractor developed the Incident Response Plan (IRP) with stakeholder consultation with Fire & Rescue NSW, NSW Police Force and Ambulance Service of NSW.
3. The Construction Contractor developed a draft protocol to demonstrate the integration of the systems to meet the objectives defined in condition B7 of the Infrastructure approval (This document)

4. Roads and Maritime Services (RMS) and Transport Management Centre (TMC) along with other agencies have worked collaboratively on the development of this Protocol, as required by condition B7 of the Infrastructure Approval, with a meeting conducted on 14 June 2018.
5. The Construction Contractor engaged WSP-Opus as an independent ventilation specialist to review the Protocol and confirm that the conditions of the Infrastructure Approval are satisfied.
6. Consultation with the Environmental Protection Authority (EPA) has been finalised. The EPA reviewed the latest information provided by the Project relating M4 East dispersion modelling study comparison between the final design and the EIS dated 21 November 2018. On the 6th December 2018 the EPA agreed that the final design achieves an equivalent of better environmental outcome than presented in the EIS/SPIR, satisfying the requirements of the Ministers Condition of Approval B3.
7. The independent ventilation specialist reviewed the M4 East dispersion modelling study comparison between the final design and the EIS dated 21 November 2018 and the evidence of consultation with the EPA. They concluded on 19 December 2018 that the required integration of the ventilation / traffic management systems, as outlined in the Ministers Conditions of Approval B7 will be met by the Project.

3 Demonstration of Minimum Velocities

In accordance with the WestConnex M4 East Infrastructure Approval Part B Environmental Performance condition B3, the Construction Contractor has finalised consultation with the EPA, to demonstrate that an equivalent or better outcomes than presented in the Proponent's most up to date air assessment was achievable. This included provision of the M4 East Tunnel Ventilation Dispersion Report and an extract from the M4 East EIS, Appendix H - Air quality impact assessment, which outlines the emission rates from the two ventilation outlets.

4 Review of this Protocol

The Construction Contractor has engaged a suitably qualified and experienced independent ventilation specialist to confirm that, before the tunnel is open to traffic, the ventilation/traffic management systems would operate together to ensure that the conditions of the approval are met as required by the Part B Environmental Performance B7 of the Infrastructure Approval.

5 Description of the Tunnel Ventilation System

The M4E Tunnels in free flowing traffic conditions takes in air from entry and exit portals and exhausts all of this air from the ventilation facilities.

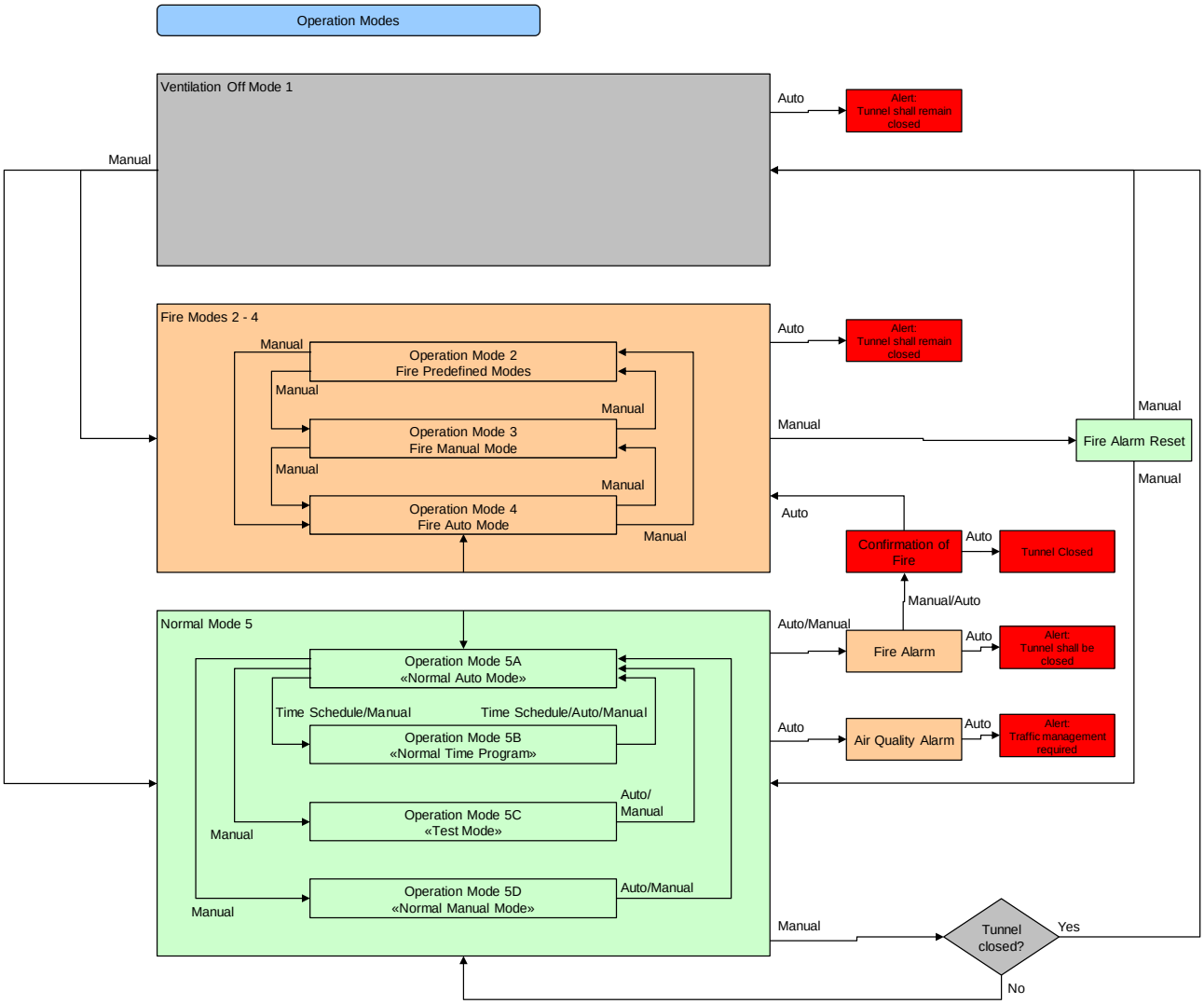
The exhaust air is ducted via dedicated underground ventilation tunnels to exhaust ventilation stations and outlets located at Parramatta Road and Underwood Road. There is an additional ventilation facility at Cintra Park which is connected to both the westbound and eastbound tunnel. These serve to extract smoke in case of a fire event from the affected tunnel.

The overall ventilation system comprises of:

- Exhaust fans;
- Supply fans;
- Jet fans (reversible where required);
- Shutoff and balancing dampers;
- Air flow, pollution and thermal measurement equipment both in tunnel and at the outlet; and
- Plant Management and Control System (PMCS)

These will operate together with the traffic management control system to ensure all air quality requirements detailed in the conditions are met for all normal, congested, incident and fire conditions managed in accordance with Incident Management Procedures (IMPs) as discussed in Section 6 below. Maintaining these air quality limits will additionally ensure that the limits specified in conditions E9 and E14 are not exceeded.

The following figure provides an overview of the control modes available to the operators to exercise control of the ventilation system:



The following provides a description of the functionality available in each mode of operation:

- "Ventilation Off Mode" (Operation Mode 1) is the mode for switching off the tunnel ventilation. All automatic sequences are switched off. All actuators can be operated manually or remotely via the OMCS. Prior to entering this mode, the operator shall be prompted to check that all tunnel users have left the tunnel, following confirmation, the operator shall be prompted to close the tunnel, noting that the ventilation system shall not execute an automatic closure of the tunnel;

- "Fire Predefined Modes" (Operation Mode 2) is the standard mode for the fire-fighting phase, it shall only be activated, if agreed with the Fire Services Agency, the operator shall be prompted prior to activation and a selection of various ventilation settings shall be made available. All ventilation devices selected to "auto control", are controlled in this mode.;

- "Fire Manual Mode" (Operation Mode 3) is another mode for the fire-fighting phase, Fire Manual Mode provides to operator with full flexibility to manually control the ventilation equipment during a fire event, this mode shall only be activated, if agreed with the Fire Services Agency;

- "Fire Auto Mode" (Operation Mode 4) is the standard Fire Operation Mode for the "self-rescue phase", the main purpose for this mode is to control the smoke spreading in order to keep tunnel users as long as possible in a smoke-free part of the traffic space, the ventilation system is operating under automated control with no manual control required. All ventilation devices selected to "auto control", are controlled in this mode, although that the operator may manually control each device by individually selecting the device and changes its control mode.. The manual control of individual ventilation units during the event of a fire has to be performed with caution as any actuator switch to manual control will be unavailable for the automatic program.

- "Normal Manual Mode" (Operation Mode 5D) is a sub-mode of "Normal Mode" (Operation Mode 5), the main purpose of this sub-mode is to manually deactivate the automatic ventilation level switching for each ventilation zone, upon entry to this sub mode, the previous ventilation level is maintained, the ventilation level can be increased or decreased manually by the operator.

  If air-quality or traffic criteria are exceeded by the real measurements, plus (thresholds and time delays), the "Normal Manual Mode" (Operation Mode 5D) is aborted. The operation mode automatically switches back to "Normal Auto Mode" (Operation Mode 5A), additionally the system shall be prevented from entering this mode if the air-quality or traffic criteria are exceeded. All ventilation devices selected to "auto control", are controlled in this mode;

- "Test Mode" (Operation Mode 5C) is a sub-mode of "Normal Mode" (Operation Mode 5), the main purpose of this sub-mode is to enable testing of the "Normal Auto Mode" and all "Fire Modes" under traffic without closing the tunnel.
  "Test Mode" is started with "Normal Test Mode" and shall have the same automatic program operating as the Operation Mode "Normal Auto Mode" (Operation Mode 5A).

  If air-quality or traffic criteria are exceeded by the real measurements, plus (thresholds and time delays), the "Normal Manual Mode" (Operation Mode 5D) is aborted. The operation mode automatically switches back to "Normal Auto Mode" (Operation Mode 5A), additionally the system shall be prevented from entering this mode if the air-quality or traffic criteria are exceeded. All ventilation devices selected to "auto control", are controlled in this mode;

- "Normal Time Program" (Operation Mode 5B) is a sub-mode of "Normal Mode" (Operation Mode 5), the main reason for this sub-mode is to operate special programs according to a free programmable time schedule, e.g. flushing of the stump. The operator is prompted when this mode is active.
  The ventilation system is still operating fully automatic with the same settings as in Operation Mode 5A. But additionally, special programs can be started automatically according to a free programmable time schedule.

  If air-quality or traffic criteria are exceeded by the real measurements, plus (thresholds and time delays), the "Normal Time Program" (Operation Mode 5B) is aborted. The operation mode automatically switches back to "Normal Auto Mode" (Operation Mode 5A), additionally the system shall be prevented from entering this mode if the air-quality or traffic criteria are exceeded. All ventilation devices selected to "auto control", are controlled in this mode;

- "Normal Auto Mode" (Operation Mode 5A) is the standard mode of "Normal Mode" (Operation Mode 5) with the highest priority. The ventilation system is operating fully automatic.

  If air-quality or traffic criteria are exceeded in any of the lower operation modes, this is automatically engaged. The ventilation level can be increased manually for each zone. Individual actuators can be remotely switched to "manual control" and can be controlled remotely. In "manual control" mode, the actuator will become unavailable for the automatic control program. The remaining actuators are still in "auto control" and are controlled by the automatic program, and will recognise the reduced availability and continue operating in the "auto control" program. The lower operation modes are "Normal Time Program", "Test Mode" and "Normal Manual Mode". All ventilation devices selected to "auto control", are controlled in this mode.

Fire and life safety of the tunnel users, tunnel workers and emergency services personnel under fire and smoke emergency conditions will also be achieved by the use of the ventilation system in conjunction with the traffic management systems to:

- Minimise queued congested conditions in the tunnels so that a downstream longitudinal smoke exhaust path is available should a fire break out;
- Ensure smoke back layering is avoided to protect upstream occupants should a fire break out; and
- Allow timely evacuation of downstream (and other if needed) occupants via pressurised cross passages and long egress passages should a fire break out in congested traffic conditions.

The latter is achieved via a pressurised cross passage system consisting of a variable speed drive controlled fan above each cross passage door. This fan will achieve a positive 50Pa static pressure differential to the fire tunnel when the cross passage door is closed and a minimum flow of 1m/s into the fire tunnel when this door is held open. Similarly long egress passages are pressurised via an LEP pressurisation system to prevent smoke and ingress. In the event of an emergence or incident situation that results in one tube being evacuated, the non-incident tube will be pressurised via the jet fans which assist in preventing smoke ingress through the mainline cross passages during a fire incident.

Annexure B of the M4E Tunnel Ventilation Dispersion Report presents the diurnal profiles from the modelling that were applied for each outlet. The purpose of the modelling was to compare the air quality impacts from the proposed ventilation design with those from the EIS design to demonstrate that air quality impacts would not be worse than the EIS. A variable velocity modelled for East (Parramatta Road) Stage 1B and West (Underwood Rd) Stage 1B, with the variable velocity for the Do Something Scenario 2021 included in Table 2 and a minimum velocity for the Regulatory Worse Case (RWC) scenario included in Table 3.

Table 2: Variable outlet exit velocity – 2021 Do Something Scenario

	Outlet exit velocity by flow regime (m/s)		
Ventilation outlet	'Low'	'Medium'	'High'
PRVF	4.3	5.8	9.4
URVF	9.3	9.2	9.7

Table 3: Minimum outlet exit velocity – RWC

	Outlet exit velocity by flow regime (m/s)	
Ventilation outlet	EIS	Ventilation outlet
PRVF	4.3	PRVF
URVF	9.3	URVF

The Tunnel Ventilation System is part of the overall Plant Monitoring and Control System (PMCS). All associated hardware is configured in a fully redundant fashion to prevent any single points of failure and consists of the following major components.

- Redundant Operator Workstations;
- Redundant Application/Database Servers;
- Redundant Communications Network (100Mbit/s Ethernet on fibre optic);
- Redundant Plant Controllers (PLCs);
- Redundant Input/Output networks;
- Distributed 110VDC to control Switchboards, Motor Control Centres and field equipment;
- Physical Devices such as fans, dampers, air quality sensors, etc.

The PMCS and its equipment derive power through two diverse 33kV feeds from the energy supply authority. Each 33kV feed is capable of powering the M4E Tunnel system. The computing elements, communications equipment and some essential PMCS equipment is further supported by Uninterruptible Power Supplies (UPS).

PMCS software is structured in the following fashion:

- Device management modules - for the control and alarming of each piece of PMCS plant e.g. fans, dampers, lights etc;
- Function management - for the control and alarming of coordinated functions such as ventilation, CO exposure calculation, lighting, drainage etc.
- System functions such as alarm handing, logging, user security etc.

Each of the above items is implemented in three domains:

- Human Machine Interface (HMI);
- Application server and database; and
- PLCs.

The ventilation control system software module takes in measurements of CO, visibility, air flow and NO_2 levels from sensors located in the tunnel. The quantities are 22 off air quality sensors and 50 off air speed sensors. Using these inputs, along with traffic flow, traffic speed and traffic incident offset (from the TMCS), the software determines the required level of ventilation to be operated (refer to Figure1). Each configurations is characterised by airflow in each section of the tunnel, and is implemented by operating corresponding numbers of supply, exhaust and jet fans within of the tunnel.

Redundancy of the ventilation capacity has been provided for loss of equipment due to the effects of a fire as well as other mechanical failures. The ventilation design report details the minimum number of jet fans required to satisfy design air quality cases. The criteria to force closure of the tunnel exists when the ventilation system cannot attain critical velocity. The loss of a number of jet fans which result in a loss of ability to maintain air quality within acceptable operating limits would satisfy high alert criteria. Available redundancy is detailed by HBI and detailed in the Reliability, Availability and Maintainability Case Report (M4E-CSJ-TR-00-120-110001).

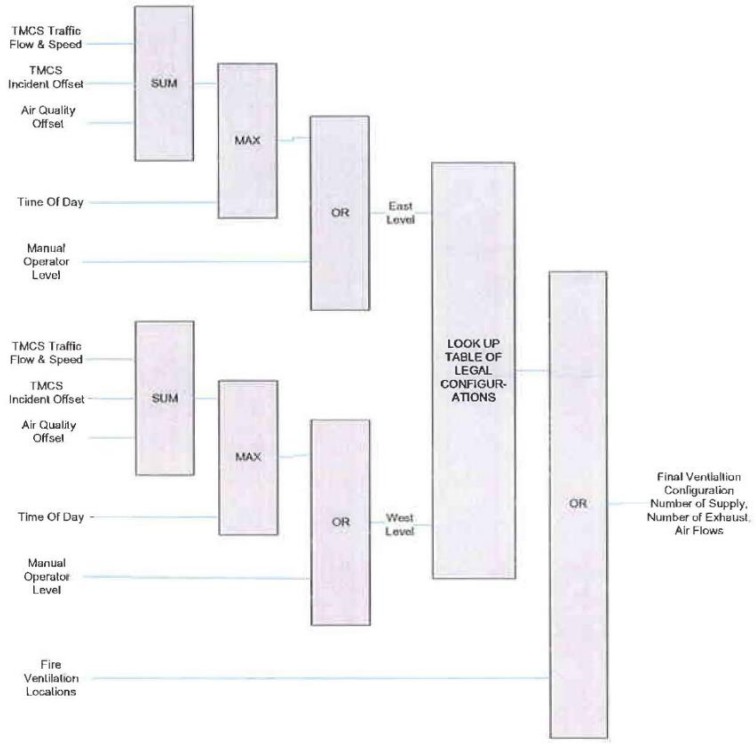


Figure 1: Ventilation Logic Block Diagram

The tunnel ventilation system design is based on and fully complies the requirements of Fire Safety Engineering Study, document reference number M4E-SGA-TR-60-480-003001.

6 Description of Traffic Management System

The Traffic Management and Control System (TMCS) controls the operation of traffic control and driver advisory devices in and around the M4E Tunnel. Real time traffic and incident information is then transferred from the OMCS to RMS and TMC systems via the Centre-to-Centre (C2C) interface.

The TMCS devices are designed to be operated manually and/or automatically and can be used as a means of limiting or stopping vehicles entering the tunnel (i.e. avoiding congestion) which, if required, could be used to control air quality. Altering of traffic flow is determined by an incident and managed and actioned by approved Incident Management Procures (IMPs) and Traffic Control Plans (TCPs).

Control modes available to the operators to exercise control of the ventilation system include: normal mode (automatic mode), manual mode and fire mode. Further detail regarding available modes of operation are detailed within the Tunnel Ventilation Controls Report.

The TMCS hardware is configured in a fully redundant fashion similar to, but separate to the PMCS. It consists of the following major blocks:

- Redundant operator workstations (Integrated with PMCS);
- Redundant application/database servers;
- Redundant communications network;
- Redundant PLCs;
- Distributed I/O to control field equipment;
- Physical devices such as ISLUS, VMS, TMS, etc.

The TMCS and its equipment within the Tunnel, derive power through same distribution network used for the PMCS. The computing elements, communications equipment and some essential TMCS equipment is further supported by Uninterruptible Power Supplies.

TMCS software is structured in the following fashion:

- Device Management Modules - for the control and alarming of each piece of TMCS equipment e.g. TMS, CMS, ISLUS etc;
- Function Management - for the control and planning coordinated functions such as Incident Detection, Incident Alert, Incident Management, etc;
- System functions such as Alarm Handing, Logging, User Security etc.

Each of the above items is implemented in three domains:

- Human Machine Interface;
- Application Server and Database; and
- Programmable Logic Controller.

The following block diagram (Figure 2) depicts the information and process flow through the TMCS incident management software.

Traffic monitoring devices (traffic loops, over height detectors, etc) provide data for incident detection. For detection of traffic flow anomalies APID and McMaster algorithms are used to create and send alerts to the TMCS Operators. Alerts are also created for over-height, emergency telephone, breakdown bay usage and air quality threshold events (from PMCS). The operators review alerts, and if necessary, declare a traffic incident. From the type and location of the alert, the operator is prompted with a selection of applicable Traffic Control Plans (TCPs) available to be implemented. The TCPs are a predefined collection of device settings based on Incidents Response Plans (IRPs).

The TMCS determines the required device settings during all active incidents to provide an output to the relevant devices. This resolution is based on setting priority (e.g. a Closed ISLUS aspect has priority over a

Caution aspect on the same ISLUS). During an incident the TMCS can send outputs which provides an offset to the ventilation levels as required. This offset is combined with the ventilation levels determined from the traffic statistics (flow and speed).

All traffic incidents have a ventilation offset that permits the operator to increase the ventilation level above the automatic level determined through the normal control system. This provides additional flexibility to allow for varying traffic conditions within the operation of an incident.

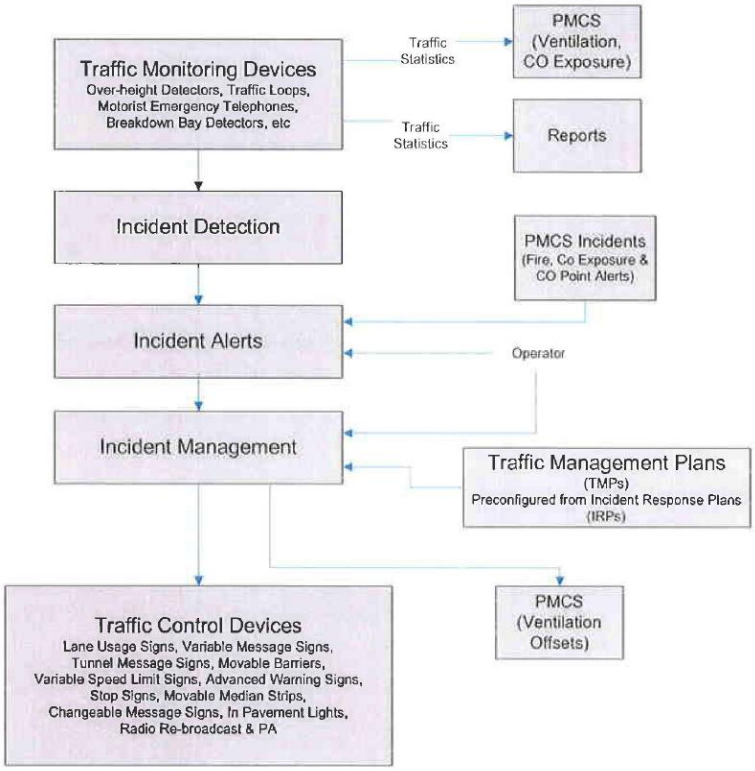


Figure 2: TMCS Incident Management Block Diagram

In addition to the automatic detection of incidents, the M4E Tunnel will have an extensive CCTV network, to allow trained operators (on 24 hours per day) to monitor the tunnel to detect possible and actual incidents in the tunnel

7 Integrated System Design Approach

While the PMCS and TMCS are stand-alone to guarantee high level of redundancy, there is a high level network link between the two systems for the transmission of traffic data to the plant system for air quality and ventilation control, and plant based alert data to the traffic system to allow the operator to manage incidents as a result of these alerts. The interface to both of these systems is combined and displayed on one set of displays that is presented to the operator. A pictorial representation of this integration and data flow is shown in the Figure 3.

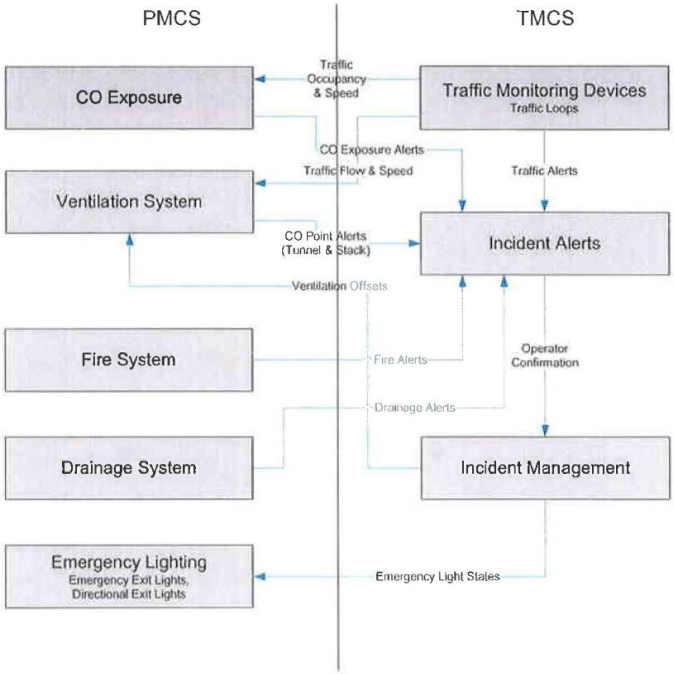


Figure 3: Inter-System Data Flows

The PMCS will control ventilation equipment, as described above, to maintain a high quality ventilation environment within the tunnel that satisfies the air quality limits specified in the condition of approval. Further, the PMCS is monitoring air quality, fire detection and tunnel drainage to bring potential problems to the attention of the operator. The TMCS is monitoring the traffic speed and flow through the tunnel and bringing anomalous traffic flow to the attention of the operator.

If anomalous traffic flow or any of the other events described above is detected by the system, an alert is generated. The operator, after investigation with CCTV or in consultation with others, may promote the alert into an incident. The operator is then presented with a selection of suitable TCPs to control the traffic around the incident. When the TCP is implemented, the traffic control devices will be automatically set to the required display. The operator may adjust the operation of the ventilation system, in anticipation of the traffic impact on ventilation. This adjustment is associated with the incident and will be cleared when the incident is cleared by the operator.

The displays and controls for the operator are integrated in a seamless set of displays. The operator need not be concerned with which system (TMCS or PMCS) the data is associated. The tunnel ventilation system is capable of fulfilling incident conditions with traffic a capacity and the minimum average vehicle speed is at least 20 km/h as specified in the Scope of Works and Technical Criteria (SWTC). During lower average vehicle speeds the traffic management system assists the ventilation system by controlling the amount of traffic entering the tunnel and therefore the produced pollution, which impacts the required tunnel ventilation capacity to achieve and/or maintain air quality levels in the tunnel. It should be further noted, that the best outcome both in terms of motorist experience and fire and life safety is achieved by an integrated response using both ventilation and traffic management systems.

8 Incident Response Plan (IRP)

The Incident Response Plan is a high level document primarily used to identify the management structure, systems, integrated processes and procedures that the operator will use in carrying out Incident Management for the M4E. It also introduces the user to the Incident Response Procedures and Safe Operating Procedures, which outline how the systems are utilised as part of a procedural response in managing incidents. The primary method of executing these plans is via the OMCS through Traffic Control Plans (TCPs).

The IRP comprises the following documents:

- Incident Response Procedures - as stated above;
- Safe Operating Procedures - as stated above;
- Traffic Control Plans (TCPs) - that contain a combination of device settings designed to manage traffic in accordance with the requirements of an IMP.

The effective implementation of the Incident Response Plan shall ensure that the O&M Contractor complies with relevant legislation, standards and codes of practice, and that the utilisation of traffic and plant management systems and procedures is integrated seamlessly with automatic operational modes.

Implementation of the Incident Response Plan and associated documentation shall be verified by periodic audits performed by internal auditors.

The purpose of the M4E Incident Response Plan is to establish the procedures for the response to, and recovery from, emergencies and incidents that may occur during the M4E operation.

The objectives of the M4E Incident Response Plan are to:

- Provide a safe road network;
- Detail procedures for response to and recovery from emergencies and incidents;
- Ensure seamless integration between the automatic system operation and any required manual intervention to ensure operation remains within requirements;
- Outline procedures for liaison with RMS and other relevant service agencies during incidents;
- Define the roles and responsibilities of the O&M Contractor personnel responding to incidents;
- Minimise damage to property;
- Minimise secondary incidents;
- Provide disaster and contingency plans to minimise delays and maximise lane availability;
- Facilitate access and suitable working conditions for emergency services by providing effective traffic management;
- Provide effective and relevant guidance with an emphasis on maintaining readiness for potential incidents or emergencies;
- Provide criteria and means to measure the achievement these objectives.

Control of ventilation and fire/smoke management systems is particularly relevant in the following Incident Management Plans:

- In Tunnel Air Quality
- Fire/Smoke
- Congestion Risk Prevention
- System Failure or Degradation.

The Incident Response Plan and associated procedures have been subjected to a rigorous stakeholder consultation process ensuring significant consultation with the Fire & Rescue NSW, NSW Police Force and Ambulance Service of NSW. All relevant plans have been tabled for discussion at workshops with these agencies with comments being addressed by amendment of the plans. Final tests of the IRP will be conducted via staged emergency exercises involving these agencies, as required by conditions E39 and E40.

8.1 In Tunnel Air Quality

This procedure details the steps taken by the operator in assessing the ventilation and air quality monitoring systems and applying staged traffic management where the automatic ventilation system is not able to effectively maintain in tunnel conditions within the air quality limits. It may be initiated alone or as part of a response to another incident, be that traffic or system / equipment related.

8.2 Fire / Smoke

Fire / smoke details the steps taken by the operator in the detection and management of fire or smoke on or near the tunnel carriageways. For ventilation purposes a fire mode must be implemented to optimise motorist safety. Traffic must be managed in accordance with this ventilation mode. It covers vehicle fires in or around the tunnel, and fires in the tunnel asset itself, such as plant rooms and the like, regardless of incident size.

8.3 Congestion Risk Prevention

This procedure details the steps taken by the operator in managing average in tunnel traffic speeds to mitigate against Fire and Life Safety (F&LS) risk. Again, a staged traffic management approach is employed to achieve this. It is required so that in the event of an in tunnel fire requiring immediate use of the deluge, the F&LS risk to downstream motorists remains manageable.

8.4 System Failure or Degradation

System failure or degradation procedure details the steps taken by the operator in the detection and management of a specific condition in the tunnel or an associated asset. It covers all M&E devices in the tunnel and associated infrastructure, including ventilation stations. It may be initiated alone or as part of a response to another incident such as in tunnel air quality.

9 Commissioning Procedures

The ventilation and traffic management systems will be thoroughly tested during and following completion of the construction phase. The commissioning will be carried out in a progressive manner to determine whether there are any shortcomings in performance of any part of the plant, equipment or installation. A substantial, detailed commissioning plan has been prepared and is presented as an Appendix to this Protocol (refer to Appendix A).

Wherever possible the testing of individual items of equipment will have been carried out in the factory, or vendor premises, before delivery to site. This provides for the most efficient testing and rectification of defects. Relevant Factory Acceptance Test (FAT) certificates and results will complement the testing that will be done on site, where required to ensure integrity after site installation. Some equipment that has already been subjected to FAT, will be re-tested during site commissioning.

The overall Commissioning Plan and testing procedures, ITPs and ITCs will be developed for each sub-system, system and integrated commissioning of all Tunnel services. The ITPs will nominate agreed "witness" and "hold" points by parties external to CSJ, such as Independent Certifier and RMS.

It is envisaged that the O&M Contractor, FHEOM, will be actively involved in the commissioning activities to gain familiarity with the installed systems and gain practical applications skills following the project operation and maintenance documentation.

The testing and commissioning phase will be carried out to demonstrate the following:

- The plant (ventilation, traffic control and all other mechanical, hydraulic, electrical, control and communication) systems and subsystems, or parts thereof, operate in correct manner and in accordance with the design objective;
- The plant meets requirements of occupational health and safety legislation and other statutory requirements as nominated in the contract and relevant standards and regulations;
- The plant interfaces in appropriate manner with systems, subsystems, equipment and services provided by others, particularly RMS.

The integrated system testing will include fire simulation and smoke testing. This will be undertaken in addition to the simulated emergency response exercise to satisfy condition E40.

Emergency Services exercises will be carried out as part of level 6 commissioning activities in accordance with the approved Incident Response Plan, as required by condition E39. This activity will involve relevant emergency services agencies and will be the final test of the Incident Response Plan.

Prior to the opening of the project to traffic, a full audit of the fire and life safety system will be undertaken by an accredited fire engineer in accordance with condition E43.

At the completion of commissioning, the plant shall be ready for operation in a reliable and safe manner.

Successful completion of commissioning will provide a precondition to handover of the plant to the O&M Contractor and opening the Tunnel to traffic.

10 Conclusion

This Protocol meets the requirements of conditions B3 and B7. It briefly outlines the components which make up the overall system for the control and management of air quality in and around the tunnel using the tunnel ventilation system and plant management system, the traffic management and overall control systems. Further detail on these components is found in the documentation listed in Section 11.

11 Reference Documentation

WestConnex M4 East Project Specifications:

(1) WestConnex M4 East Infrastructure Approval

(2) WestConnex M4 East Scope of Works and Technical Criteria

Ventilation Technical Reports:

(3) Tunnel Ventilation Report, M4E-HBI-TR-00-120-061001

(4) Tunnel Ventilation Control Report for Stage 1, M4E-HBI-TR-00-120-061002

(5) Tunnel Ventilation Dispersion Report, M4E-CSJ-TR-60-420-165001

(6) M4 East dispersion modelling study comparison between the final design and the EIS dated 21 November 2018

OMCS Technical Reports:

(7) 60_20 OMCS Architecture and Hardware Design Package Report, M4E-SCE-TR-60-540-380001

(8) OMCS Software Design Package Report, M4E-SCE-TR-60-540-382001

(9) TMCS Functionality Technical Report, M4E-SCE-TR-60-540-382021

Fire Systems Technical Reports:

(10) Fire Engineering Brief, M4E-SGA-TR-60-480-002001

(11) Fire Engineering Report, M4E-SGA-TR-60-480-003001

Typical Testing and Commissioning Procedures

(12) ITP L2- L4 Mechanical Commissioning Ventilation M4E-CG-ITP-MEW-06856-04-VE_12010_M

(13) Instrument Test Record, M4E-CG-CKL-MEW-05641

(14) ITR Axial Fan Run Test M4E-CG-CKL-MEW-06591

(15) ITR Level 3 Fan I/O, M4E-CG-CKL-MEW-08361

(16) ITR LV Motor, M4E-CG-CKL-MEW-05674

Appendix A

M&E Test and Commissioning Plan M4E-CP-PLN-PWD-02558