Tunnel Ventilation, Incident Response and Traffic Management System Integration Protocol

M4-M5 LINK TUNNELS PROJECT

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A	**06/10/2022**	**First issue for consultation**
B	**03/11/2022**	**Revised to address TMC & Ventilation Specialist Comments**
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Terms and Definitions

Term	Definition
Company	WestConnex
Contractor	Acciona Samsung Bouygues Joint Venture (ASBJV)
Deed	WestConnex 3A D&C Deed
Independent Certifier	Reviews the design and construction output to ensures that each party meets their obligations in accordance with the requirements of the contract.
Subcontractor	The party providing the specified design and equipment
Scope of Works and Technical Criteria	Exhibit M of the Deed
Specification	A document that sets out the requirements and parameters, that the design and/or construction must meet.

Abbreviations

Abbreviation	Definition
AHD	Australian Height Datum
AS	Australian Standard
ASBJV	Acciona Samsung Bouygues Joint Venture
ANZECC	Australian and New Zealand Environment and Conservation Council
ATLOS	Average Traffic Level of Service
CO	Carbon Monoxide
CSSI	Critical State Significant Infrastructure
C2C	Centre-to-Centre
D&C	Design and Construction Project
EIS	Environmental Impact Statement
ERP	Emergency Response Plan
FAT	Factory Acceptance Test
IC	Independent Certifier
IFC	Issued for Construction
IFV	Issued for Verification
IMS	Incident Management System
IOMCS	Integrated Operations Management and Control System
IRP	Incident Response Plan
IRPs	Incident Response Procedures
ISLUS	Integrated Speed and Lane Usage Sign
ITC	Inspection and Test Checklist
ITP	Inspection and Test Plan
i-VCS	Integrated Ventilation Control System

Abbreviation	Definition
M4E	M4 East tunnel (stage 1b)
MCoA	Minister's Conditions of Approval
M&E	Mechanical & Electrical
NM5	New M5 tunnel (stage 2)
NOx	Oxides of Nitrogen
NO2	Nitrogen Dioxide
O&M	Operation and Maintenance
OMCS	Operations Management and Control System
PM2.5	Particulate matter (2.5 micrometres or less in diameter)
PM10	Particulate matter (10 micrometres or less in diameter)
The Project	M4-M5 Link Tunnels project (also WestConnex Stage 3A)
RFI	Request for Information
PMCS	Plant Monitoring and Control System
S1-VCS	Stage 1 Ventilation Control System
S2-VCS	Stage 2 Ventilation Control System
S3-VCS	Stage 3 Ventilation Control System
SCADA	Supervisory Control and Data Acquisition
SiD	Safety in Design
SPI	St Peters Interchange
SPIR	Submissions and Preferred Infrastructure Report
SSI	State Significant Infrastructure
SWC	Sydney Water Corporation
SWTC	Scope of Works and Technical Criteria
TCP	Traffic Control Plan
TCRO	Traffic Control Room Officer
TfNSW	Transport for New South Wales
TMC	Traffic Management Centre
TMCS	Traffic Management and Control System
VCS	Ventilation Control System
VMS	Variable Message Sign
WCX	WestConnex (M4-M5 Link Project)

1 Introduction

1.1 Purpose

The purpose of this "Tunnel Ventilation, Incident Response and Traffic Management Systems Integration Protocol" (the Protocol), as required under Ministers Conditions of Approval E13 to E17, 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-M5 Link are achieved.

1.2 Executive Summary

The objective of this document is to demonstrate that the systems provided for the WestConnex M4-M5 Link project would operate together to ensure that the conditions outlined in the MCoA are met. Maintaining the air quality limits outlined in this document will ensure that the limits specified in condition E2A, E3, E4, E5 and E6 are not exceeded due to operation of the tunnel.

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 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-M5 Link project as a stand-alone tunnel and as a tunnel operating in conjunction with the two adjoining WestConnex project stages currently under operation.

2 MCoA Requirements for this Protocol

2.1 General

Clause	Requirement
A1	The CSSI must be carried out in accordance with the terms of this approval and generally in accordance with the description of the CSSI in the WestConnex M4-M5 Link Environmental Impact Statement – Volumes 1A-C and 2A-J (dated August 2017) (the EIS) as amended by: a) the WestConnex M4-M5 Link Submissions and Preferred Infrastructure Report (dated January 2018) (the SPIR); b) the WestConnex M4-M5 Link Mainline Tunnel Modification Report (dated September 2018) (Modification 1 Report) as amended by the WestConnex M4-M5 Link Mainline Tunnel Modification Response to Submissions (dated November 2018) (Modification 1 RtS); Items (c) through (e) refer to Rozelle Interchange and are not included here

2.2 Air Quality Design Optimisation

Clause	Requirement
E13	A Tunnel Ventilation, Traffic Incident Response and Traffic Management Systems Integration Protocol (Protocol) must be prepared in consultation with the TMC. The Protocol must be reviewed and endorsed by a suitably qualified and experienced independent ventilation specialist. The Protocol must demonstrate that the ventilation and traffic management systems would operate together to ensure conditions of this approval are met.
E14	The Tunnel Ventilation, Traffic Incident Response and Traffic Management Systems Integration Protocol must include a commissioning procedure that is to be carried out before a tunnel (or any part of it) is opened to traffic.
E15	The Tunnel Ventilation, Traffic Incident Response and Traffic Management Systems Integration Protocol must be submitted to the Secretary for information no later than one (1) month prior to commencement of operation of a tunnel (whether in full or in part).
E16	The Tunnel Ventilation, Traffic Incident Response and Traffic Management Systems Integration Protocol, must be implemented for the duration of operation.
E17	Prior to commencing operation, a person or organisation, who is independent from the design and construction of the CSSI, whose appointment has been approved by the Secretary, must review the in-tunnel ventilation and ventilation outlet design of the project and the Tunnel Ventilation, Traffic Incident Response and Traffic Management Systems Integration Protocol prepared in accordance with Condition E13 to verify that: a) the final design achieves the in-tunnel and ventilation outlet limits for all traffic conditions including congestion (as described by the regulatory worst-case scenario in Chapter 9 of the EIS); b) the predicted impacts of the final design are no greater than predicted in the documents listed in Condition A1 for the equivalent operating conditions; and c) the ventilation system has been optimised to achieve effective and responsive treatment of in-tunnel air quality and efficient energy consumption. The operating scenarios used to model the final design should be the same as those used in the documents listed in Condition A1. Should the design review adopt a modelling program different to that used in the EIS, the EIS predictions shall be re-modelled using the model adopted for the design review, to establish the predicted outcomes under part (b). The information required in this condition must be made available to the Secretary on request.

3 Air Quality Limits and Goals

The following limits are extracted from the Conditions of Approval and are applicable to the permanently installed tunnel systems. Note that the ambient air quality limits outlined in MCoA E6 are not used to actively control the tunnel ventilation system. Instances of exceedances in the ambient air quality goals will be dealt with through the notification and reporting requirements outlined in MCoA E32.

The following tables have also been included in the Conditions of Approval for both M4E (SSI 6307) and M8 (SSI 6788) projects. The following table shows congruency of the air quality limits and goals for the adjacent projects.

Table 1: Congruency of Air Quality Limits and Goals

Component	Requirement(s)	M4 East MCoA Reference	M8 MCoA Reference	M4-M5 Link MCoA Reference
In-tunnel Air Quality	Identical	E2, E3, E4	E4, E5, E6	E3, E4, E5
Outlet Air Quality	Identical	E14	E19	E2
Ambient Air Quality	Identical	E9	E14	E6

Table 2: Ventilation Outlet Air Quality Limits – MCoA E2

Pollutant / Parameter	Type of Measurement	Concentration Limit
Solid Particles (mg/m^3)	Average – 1 hour	1.1
NO2 or NO or both as NO2 equivalent (mg/m^3)	Average – 1 hour block	20
NO2 (mg/m^3)	Average – 1 hour block	2.0
CO (mg/m^3)	Average – 1 hour rolling	40
VOC (as Propane) (mg/m^3)	Average – 1 hour rolling	4.0

Table 3: In-tunnel Air Quality Limits – MCoA E3 to E5

Pollutant / Parameter	Type of Measurement	Concentration Limit
CO (ppm)	Rolling Average – 15 min	87
CO (ppm)	Rolling Average – 30 min	50
CO (ppm)	Rolling Maximum – 3 min	200
NO2 (ppm)	Rolling Average – 15 min	0.5
Visibility (m-1)	Rolling Maximum – 15 min	0.0050

Table 4: Ambient Air Quality Goals – MCoA E6

Pollutant / Parameter	Type of Measurement	Concentration Limit
CO (ppm)	Average – 8 hour rolling	9
NO2 (ppm)	Average – 1 hour block	0.12
PM10 (µg/m³)	Average – 24 hour rolling	50
PM2.5 (µg/m³)	Average – 24 hour rolling	25
PM10 (µg/m³)	Average – Annual	25
PM2.5 (µg/m³)	Average – Annual	8

Table 5: Ventilation Outlet Tip Heights – MCoA E12

Location	Outlet Reference	Outlet Elevation (m AHD)
Campbell Rd St Peters	SPI-5 / SPI-6	32.9 – 35.9
	SPI-7,	32.8 – 35.8
	SPI-8	32.6 – 35.6
Haberfield	As constructed by M4E Contractor	

4 Consultation on this Protocol

Transport Management Centre (TMC) have been involved in the development of this Protocol in accordance with the requirements of the WestConnex M4-M5 Link Infrastructure Approval.

The process for development and review for this Protocol was:

1. The Contractor developed:
   (a) The Traffic Management and Control System (TMCS) in accordance with the SWTC and WestConnex M4-M5 Link Infrastructure Approval.

   (b) The Tunnel Ventilation Design in accordance with the SWTC and WestConnex M4-M5 Link Infrastructure Approval.
2. The Contractor developed the Emergency Response Plan (ERP) with stakeholder consultation with Fire & Rescue NSW and NSW Police. The Asset Owner and the Operator developed the Incident Response Plan (IRP) and associated Protocols and Procedures (IRPs) with stakeholder consultation with Fire & Rescue NSW, NSW Police Force and Ambulance Service of NSW.
3. The Contractor developed a draft protocol to demonstrate the integration of the systems to meet the objectives defined in condition E13-E17 of the Infrastructure approval (This document)
4. Transport for NSW (TfNSW) and Transport Management Centre (TMC) were consulted on the development of this Protocol, as required by condition E13-E17 of the Infrastructure Approval.

   A draft version of the Protocol was provided to TMC on the 07/10/2022.

   A meeting was held on the 21/10/2022 with TMC, M4-M5 Link Group, TfNSW and ASBJV representatives attending.

   TMC provided comments to ASBJV on the 28/10/2022.

   A meeting was held on the 04/11/2022 with TMC, M4-M5 Link Group, TfNSW and ASBJV representatives attending.

   Comments received and discussions held during these meetings were considered by ASBJV and the Protocol has been updated to address.
5. The Contractor has engaged BG Consulting Engineers as a suitably qualified and experienced independent ventilation specialist to review and endorse this Protocol. This review concluded that the relevant Conditions of Approval have been satisfied.

5 Compliance to Ambient Concentrations

In accordance with MCoA clause E12, the ventilation outlets at St Peters have been constructed to have a tip height of RL 32.8 m relative to the Australian Height Datum (AHD).

In order to ensure compliance with clause E6, the Contractor has undertaken dispersion modelling during the design phase of the project. The results of this analysis are contained in Appendix N.1 of the ME02 design report and indicate that the ambient conditions for the regulatory worst case and design year 2033 are equal to or better than that described in the EIS.

Table 6: Haberfield – Predicted Maximum Ground Level Concentration (µg/m³)

Pollutant	Averaging Time	GRAL – EIS vs Design		GRAL – 2033 DSC		GRAL - RWC	
		EIS	Design	Cumulative	Goal	Cumulative	Goal
CO	1 hour	52.6	43.9	569.4	30,000	569.4	30,000
	8 hour	~	~	279.6	10,000	~	10,000
NOX	1 hour	28.5	28.0	~	~	~	~
	Annual	0.71	0.67	~	~	~	~
NO2	1 hour	~	~	199.3	246	201.5	246
	Annual	~	~	21.4	62	~	62
PM10	24 hour	1.2	1.1	21.1	50	~	50
	Annual	0.1	0.1	17.3	25	~	25
PM2.5	24 hour	0.8	0.7	17.1	25	~	25
	Annual	0.1	0.1	8.1	8	~	8

Table 7: St Peters – Predicted Maximum Ground Level Concentration (µg/m³)

Pollutant	Averaging Time	GRAL – 2033 DSC		GRAL – 2033 DSC		GRAL - RWC	
		EIS	Design	Cumulative	Goal	Cumulative	Goal
CO	1 hour	82.7	75.9	446.2	30,000	924.7	30,000
	8 hour	~	~	296.4	10,000	~	10,000
NOX	1 hour	63.9	54.0	~	~	~	~
	Annual	2.3	1.9	~	~	~	~
NO2	1 hour	~	~	203.7	246	209.2	246
	Annual	~	~	23.4	62	~	62
PM10	24 hour	2.6	2.6	21.9	50	~	50
	Annual	0.4	0.4	17.4	25	~	25
PM2.5	24 hour	1.7	1.7	11.6	25	~	25
	Annual	0.3	0.2	8.2	8	~	8

6 Description of the Tunnel Ventilation System

The Tunnel Ventilation System design is based on a longitudinal ventilation concept whereby the in-tunnel air quality is maintained by achieving a longitudinal flow of air through the tunnel. The tunnel airflow is generally developed in the direction of traffic flow and assisted by a series of jet fans distributed throughout the tunnels.

Typically, fresh air will be drawn in from the entry portals and pushed towards the mainline exit portals by the vehicle generated piston effect. Where the vehicle generated airflow is insufficient, such as during slow moving traffic conditions, the mainline airflow will be assisted by jet fans. The vitiated tunnel air will be then extracted from the tunnel upstream of the tunnel exit portals by ventilation fans located in the portal ventilation stations. This air will be extracted via the ventilation stations located at exit portals and inter-project boundaries.

The exhaust air is ducted via dedicated underground ventilation tunnels to exhaust ventilation stations and outlets located at Haberfield and St Peters. These buildings also 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 airflow balancing dampers;
- Air flow and pollution 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 the air quality requirements detailed in conditions E3, E4 and E5 are met for all normal and congested conditions managed in accordance with Incident Response Procedures (IRPs) as discussed in Section 8 below. Maintaining these air quality limits will additionally ensure that the limits specified in conditions E2A and E6 are not exceeded as a result of operation of the tunnel.

The following figures provide an overview of the control modes available to the operators to exercise control of the ventilation system:

Figure 1: Changing Ventilation Modes

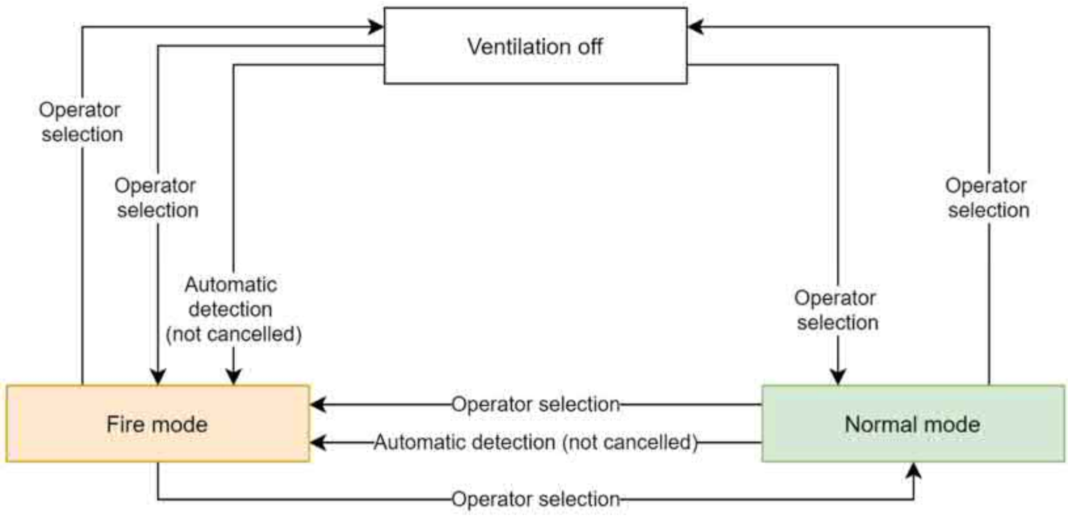
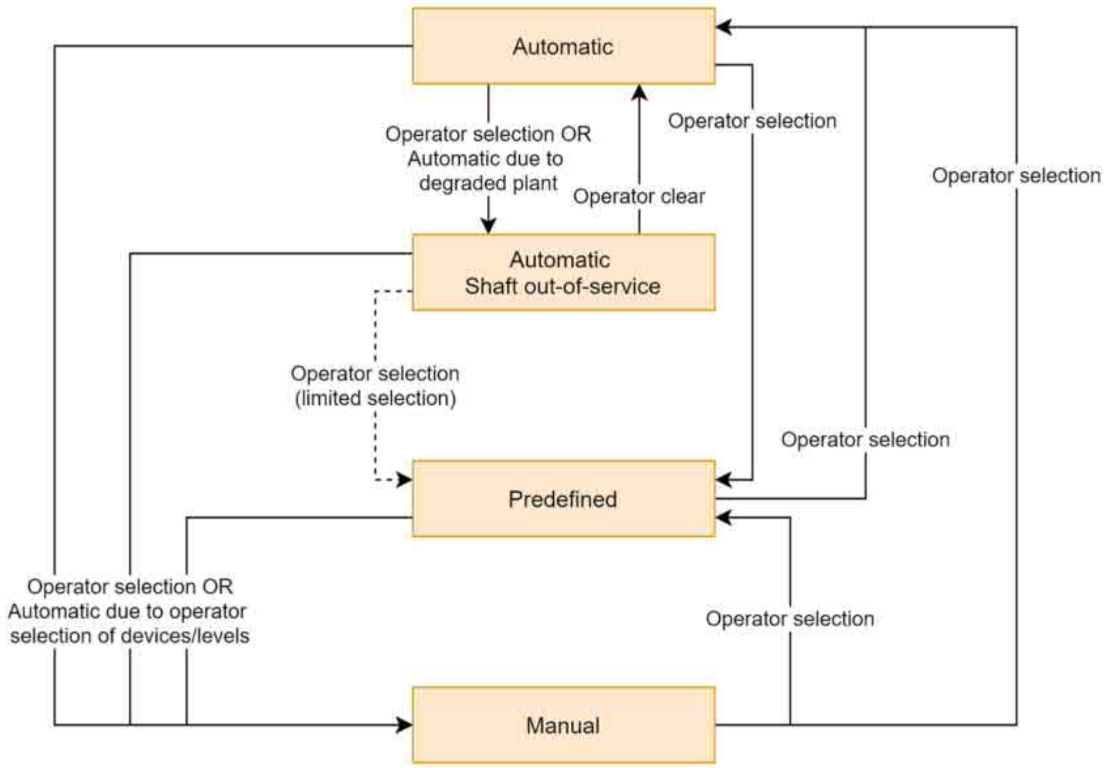


Figure 2 - Changing Ventilation Sub-Modes within Normal and Fire Modes



The following table provides a brief description of the functionality available in each mode of operation.

Table 8: Available Functionality in Normal/Fire Modes

Operation Type	Normal Mode	Fire Mode
Manual	Each device remains in the same status as the previous operation until they receive a manual command. The operator has full control of the tunnel through the management of individual devices.	
Predefined	The ventilation devices operate based on configurable mode tables. These mode tables can be changed by the operator. Some modes use feedback to control to target values and some have fixed plant responses without feedback as defined in the table.	The operation of ventilation devices is set by predetermined tables. There is no change to ventilation devices based on feedback.
Shaft out of Service Automatic	The ventilation devices are controlled automatically to meet the performance requirements while one shaft is out of service.	
Automatic	The ventilation devices are controlled automatically to meet the performance requirements. The operator has minimal control of the tunnel ventilation response. The algorithm controls most aspects of device and setpoint control.	

The Ventilation Control System (VCS) is set up primarily to ensure that the maximum pollution levels are kept under the defined limits and portal emissions are prevented. This is achieved by limiting the amount of time a sample of air spends within the tunnel.

During low speed and congested operations additional fresh air may be introduced via the air exchange function in the mainline tunnel to provide further dilution to the in-tunnel air. Using this functionality, 95% of the tunnel air can be exchanged at the M4-M5 Link boundaries.

During normal operation, the base ventilation level of the Tunnel Ventilation System will be set by the maximum of both the time-of-day table and the vehicle flow and average vehicle speed (traffic service level). Feedback from the in-tunnel and outlet air quality sensors will also be used by the VCS to activate air exchanges between stages and/or apply an offset to the ventilation level should the air quality exceed the approach air quality levels in Table 9 and Table 10 below. Further visual indication will be provided to the TCRO if stage 1 to 4 air quality levels are met or exceeded via a SCADA status display. A critical alarm will be raised and an in-tunnel or outlet air quality incident will be triggered if the MCoA limits are met or exceeded.

Table 9: In-tunnel Air Quality Set Points

Pollutant	Approach	Stage 1	Stage 2	Stage 3	Stage 4	MCoA Limit
CO - 3 min (ppm)	100	140	160	180	190	200
CO - 15 min (ppm)	35	60	70	80	84	87
CO - 30 min (ppm)	20.0	35.0	40.0	45.0	47.5	50.0
NO2 - 15 min (ppm)	0.20	0.30	0.35	0.40	0.45	0.50

Pollutant	Approach	Stage 1	Stage 2	Stage 3	Stage 4	MCoA Limit
Visibility (m-1)	0.0020	0.0030	0.0035	0.0040	0.0045	0.0050

Table 10: Outlet Air Quality Set Points

Pollutant	Approach	Stage 1	Stage 2	Stage 3	Stage 4	MCoA Limit
Solid Particles	0.88	0.90	0.95	0.97	1.00	1.10
NOX	16	17	18	19	19.5	20
NO2	1.60	1.70	1.80	1.90	1.95	2.00
CO	32	34	36	38	39	40
VOC (as propane)	3.2	3.4	3.6	3.8	3.9	4.0

The VCS will reference the normal operation look-up table, which will specify the required airflow for each section of the tunnel and the extraction requirements of the portal ventilation stations for each ventilation level.

The VCS will determine the number of jet fans required to operate to maintain tunnel air quality and prevent portal emissions under varying traffic conditions, which will be altered in response to the varying flow rates induced by traffic. There is a dead-band applied to the target airflows in each section of the tunnel to avoid unnecessary changes in jet fan operation.

The VCS will usually operate in a fully automatic manner for normal operation. However, it may be overridden or manually commanded by the operator to activate any of the pre-programmed ventilation modes or operate individual equipment in manual mode if required.

Control system functionality will generally comprise the following elements:

(a) Traffic and/or pollutant level data and/or portal emission management will determine the overall ventilation rate and target flow rates;

(b) Airflow through tunnel sections will be maintained by automatic feedback control of jet fans to meet airflow requirements; and

(c) Higher pollutant levels, as measured by the air quality sensors, will cause the VCS to increase the ventilation level.

7 Description of Traffic Management Control System

The Traffic Management and Control System (TMCS) controls the operation of traffic control and driver advisory devices in and around the M4-M5 Link 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 Response Procedures (IRPs) and Traffic Control Plans (TCPs).

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 3) depicts the information and process flow through the TMCS incident management software.

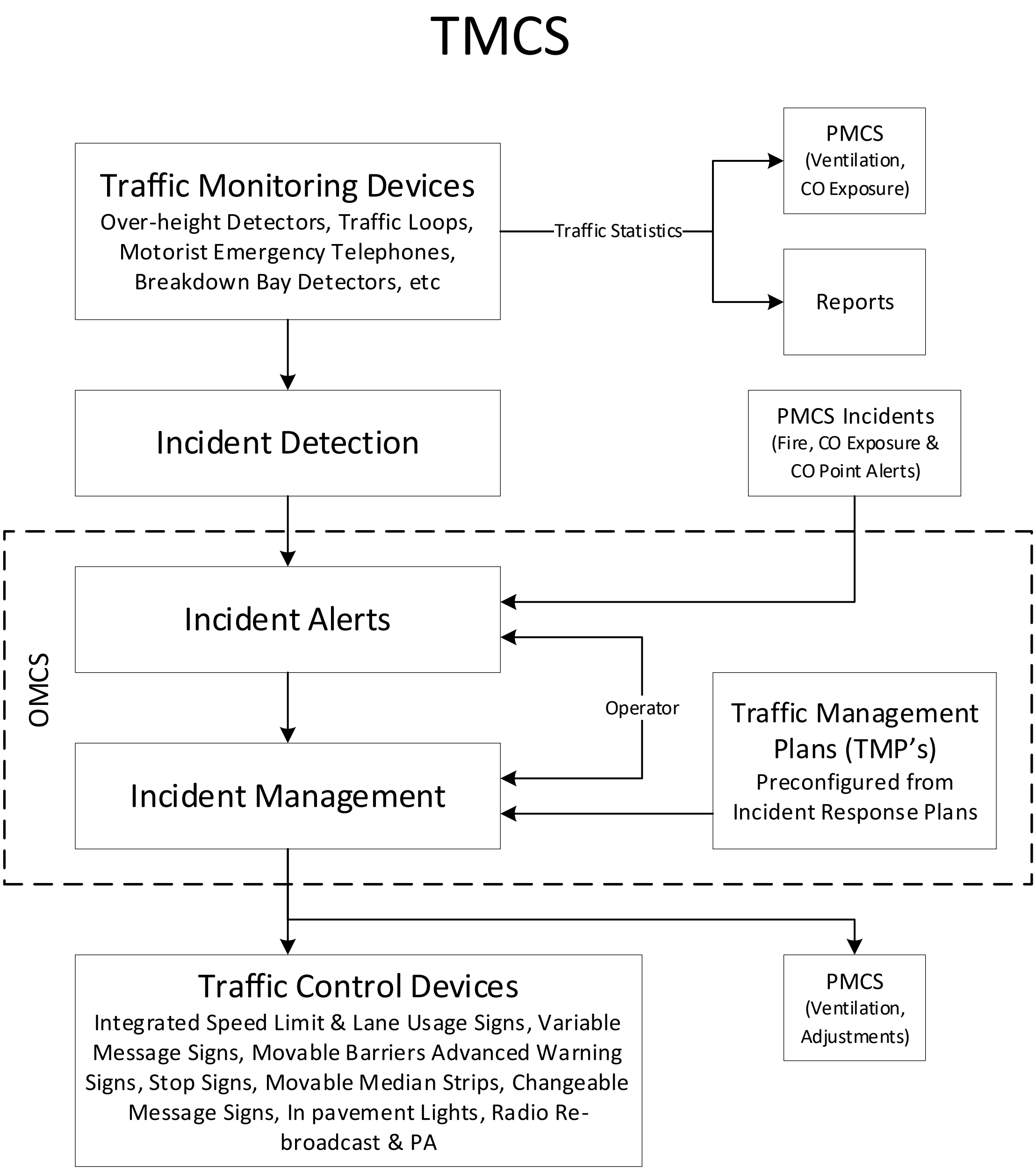
Traffic monitoring devices (traffic loops, over height detectors, etc) provide data for incident detection. For detection of traffic flow anomalies APID and McMaster algorithms are used to create and send alerts to the TCRO. Alerts are also created for over-height, emergency telephone, breakdown bay usage and air quality threshold events (from PMCS). The TCRO 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 Procedures (IRPs).

The TMCS actions the required device settings from the TCRO selected TCP during all active incidents to provide an output to the relevant devices. TMCS resolves competing actions to a single TMCS device by the use of message priority (e.g. a Closed ISLUS aspect has priority over a Caution aspect on the same ISLUS). The TMCS will not automatically operate to prevent traffic from entering the tunnel until directed to by the TCRO via a selected TCP.

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 TCRO 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 3 - TMCS Overview



In addition to the automatic detection of incidents, the M4-M5 Link Tunnel will have an extensive CCTV network, to allow trained operators (on shifts 24 hours per day) to monitor the tunnel to detect possible and actual incidents in the tunnel.

8 TVS Interactions with Other Systems

8.1 TVS Actions triggered by the TMCS

The TMCS will trigger the following actions in the TVS:

1. The base ventilation level will change due to a change in the Averaged Traffic Level of Service (ATLOS) - The ATLOS is calculated by SIDERA via traffic flow and speed data received by the TMCS from the traffic loops. The ATLOS is an integer between 1-4 and is calculated for each ventilation zone of the tunnel. The ATLOS is used by the TVS to set a minimum base ventilation level of the Ventilation Zone. A decrease in the ATLOS will only be recognised by the TVS if the ATLOS remains decreased for a period of 15 minutes.

This is tested in the OMCS PMCS Ventilation SAT Test Cases ITR (M4M5-SICE-PRW-MES-OM30-ITR-1008), where the ATLOS level will be manually increased to trigger a base ventilation level increase via a simulation screen in the OMCS. The decrease and associated time delay will also be tested.

The ATLOS and associated minimum base ventilation level table will be reviewed and modified through Level 7 testing post opening. This will be performed with live vehicle speed and traffic data to confirm the appropriateness of the ATLOS level and associated base ventilation level.

8.2 TMCS Actions triggered by the TVS

The TVS will not trigger any action in the TMCS.

8.3 TVS Actions in the Incident Management System

The following air quality events will trigger an incident in the IMS by the TVS if the associated condition is met:

1. Incident type Air Quality - sub-type In-tunnel Air Quality - if CO, NO2 or Visibility MCoA limit is exceeded;
2. Incident type Air Quality - sub-type Outlet Air Quality - if Solid Particles, NOx, NO2, CO, VOC or outlet air velocity MCoA limit is exceeded;
3. Incident type Air Quality - sub-type Segment Degraded - if more than the allowable number of fans are not available for automatic control. Allowable number of fans not available is identified in document M4M5-LSBJ-PRW-MES-ME03-SPC-0001, Appendix A, Table A.7.

This is tested in the IOMCS Incident Management System I-SIT Test Cases ITR (M4M5-SICE-PRW-MES-OM63-ITR-7008), where an exceedance of the MCoA limit is simulated to trigger an incident and associated IMS actions.

The IMS Ventilation Management tab will have the following commands and statuses available depending on the location of the incident, as identified in document M4M5-SICE-PRW-MES-OM17-RPT-0005:

- Test Mode;
- Southbound Mode;
- Southbound Predefined;
- Southbound Zone 1 Ventilation Level;
- Southbound Zone 2 Ventilation Level;
- Northbound Mode;
- Northbound Predefined;
- Northbound Zone 1 Ventilation Level;
- Northbound Zone 2 Ventilation Level;
- Southbound PRVF Exchange;
- Southbound SPI Exchange;
- Southbound SPI Flow Reversal;
- Northbound SPI Exchange;
- Northbound PRVF Exchange;
- Northbound PRVF Flow Reversal.

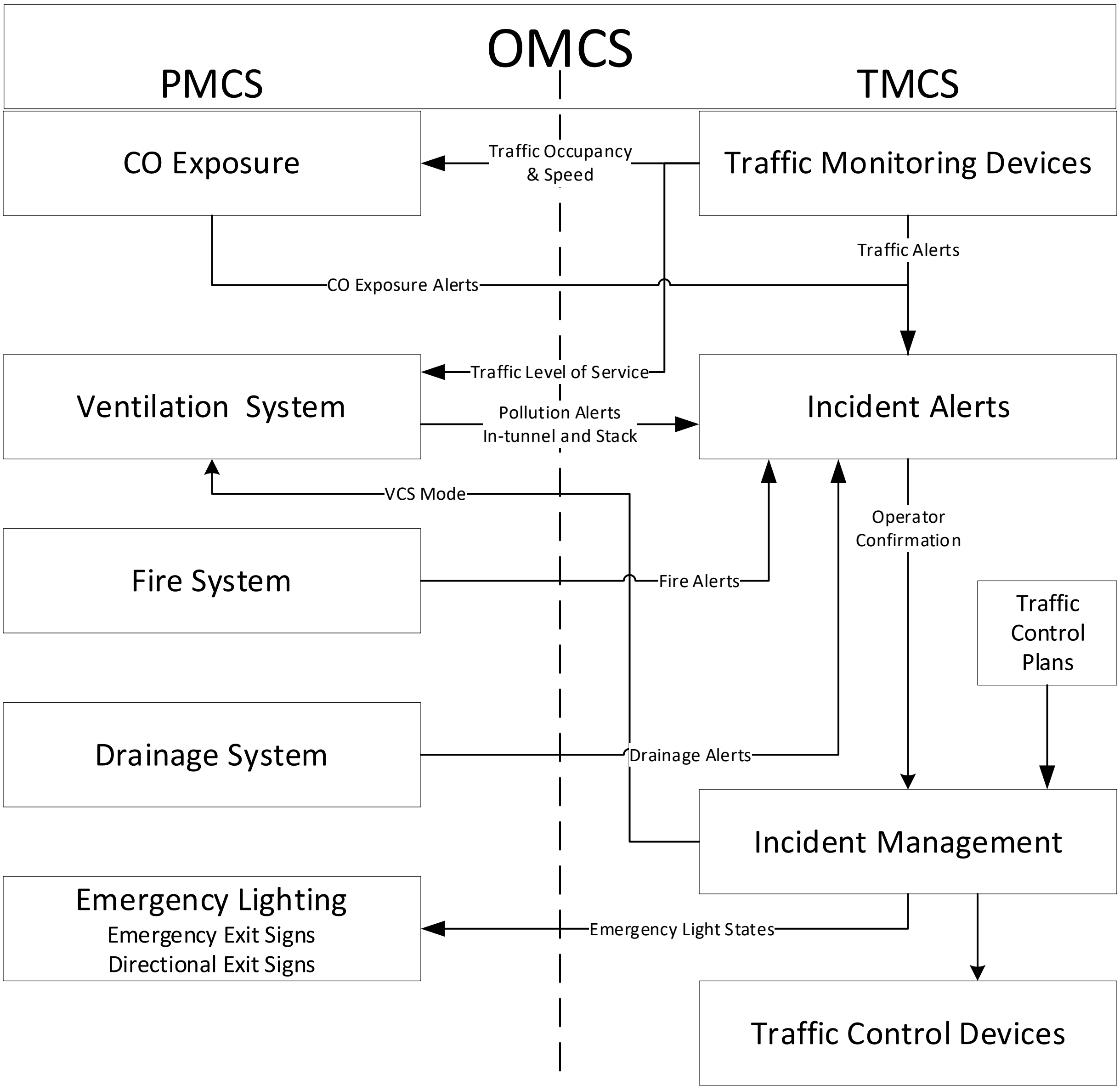
9 M4-M5 Link Tunnel Integrated System Design Approach

While the PMCS and TMCS field systems are stand-alone to guarantee high level of redundancy, with these two systems integrated via a high-level communication link with the OMCS. The TMCS and PMCS systems and their communication is supervised by the OMCS, and traffic data is made available the plant system for air quality and ventilation control, and plant based and traffic system alert data is sent to OMCS to allow the operator to manage incidents as a result of these alerts.

The OMCS provides an interface to both of the PMCS and TMCS systems in a combined graphical display that is presented to the operator.

A pictorial representation of this integration and data flow is shown in Figure 4.

Figure 4 - TMCS PMCS Interface



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 e.g. with CCTV, 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 at 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 Operator uses the traffic management control system to assist 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.

10 Possible Actions

The overarching strategy in the event of congestion is to maintain as high a speed as possible within the tunnel by restricting the amount of vehicles entering the tunnel. In this way, stalled traffic will develop outside the tunnel on the approaches.

The possible actions to deal with an incident to prevent an air quality exceedance are listed below. In addition to the steps noted below, the motorway and operators also have a variety of electronic signage that can be used to advise motorists of potential delays and possible alternative routes.

1. Increase ventilation level manually;
2. Implement suitable TCP (as outlined in WCX-OP-PR-13), e.g.:
   (a) VMS to warn motorists of congestion severity;
   (b) Close lane in tunnel to reduce capacity;
   (c) Close ramp;
   (d) Implement ramp metering.
3. Consider additional measures to manage air quality (as outlined in WCX-OP-PR-24), e.g.:
   (a) Direct motorists to turn off engines if traffic is stationary;
   (b) Request TMC relieve external network congestion if possible;
   (c) Restore ventilation fans to service if capacity is reduced due to maintenance.

Congestion leading to air quality issues will be dealt with in almost all cases through the automatic normal operation ventilation control mode and the approach set points as outlined above.

The key in implementing any or all of the above actions is around timing. As the traffic volumes vary significantly during the day and night, and an incident near the exit of the tunnel will have more of an impact on air quality than one at the entrance, the TCRO will need to closely monitor incidents and react according to the circumstances. Whilst commissioning procedures have been developed and can be tested prior to opening, these will be done based on simulated air quality data.

It is also expected that the TCRO will use knowledge developed during the tunnel operation to implement a response prior to trigger points being reached.

11 Incident Response Plan

The Incident Response Plan (IRP) is primarily used by the Asset Owner and Operator to identify the management structure, systems, integrated processes and procedures that the TCRO's will use in carrying out Incident Management for the M4-M5 Link. It also introduces the user to the Incident Response Procedures (IRPs), 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 and IOMCS through Traffic Control Plans (TCPs).

The effective implementation of the Incident Response Plan shall ensure that the Asset Owner and Operator 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 WestConnex Incident Response Plan is to establish the procedures for the response to, and recovery from, emergencies and incidents that may occur during operation of the tunnels.

Control of ventilation management systems is particularly relevant in the following WestConnex Incident Response Procedures:

- WOM-OP-PR-24 Air Quality
- WOM-OP-PR-13 Congestion
- WOM-OP-PR-19 Systems Failure or Degradation.

The Incident Response Plan and associated procedures have been developed by the Asset Owner and Operator and subjected to a stakeholder consultation process with the Fire & Rescue NSW, NSW Police Force and Ambulance Service of NSW. Final tests of the IRP will be conducted via an emergency exercise involving these agencies, as required by conditions E142 and E143.

11.1 Air Quality

This procedure details the steps taken by the Traffic Control Room Officers (TCRO) 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.

11.2 Congestion

This procedure details the requirements to be observed by the TCROs when alerted to congestion on the WestConnex motorway. The procedure requires the TCRO to refer to Air Quality procedure for advice on managing the in-tunnel air quality.

11.3 Systems Failure or Degradation

System failure or degradation procedure details the steps taken by the TCRO's 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.

12 WestConnex Motorway Integrated Ventilation Design Approach

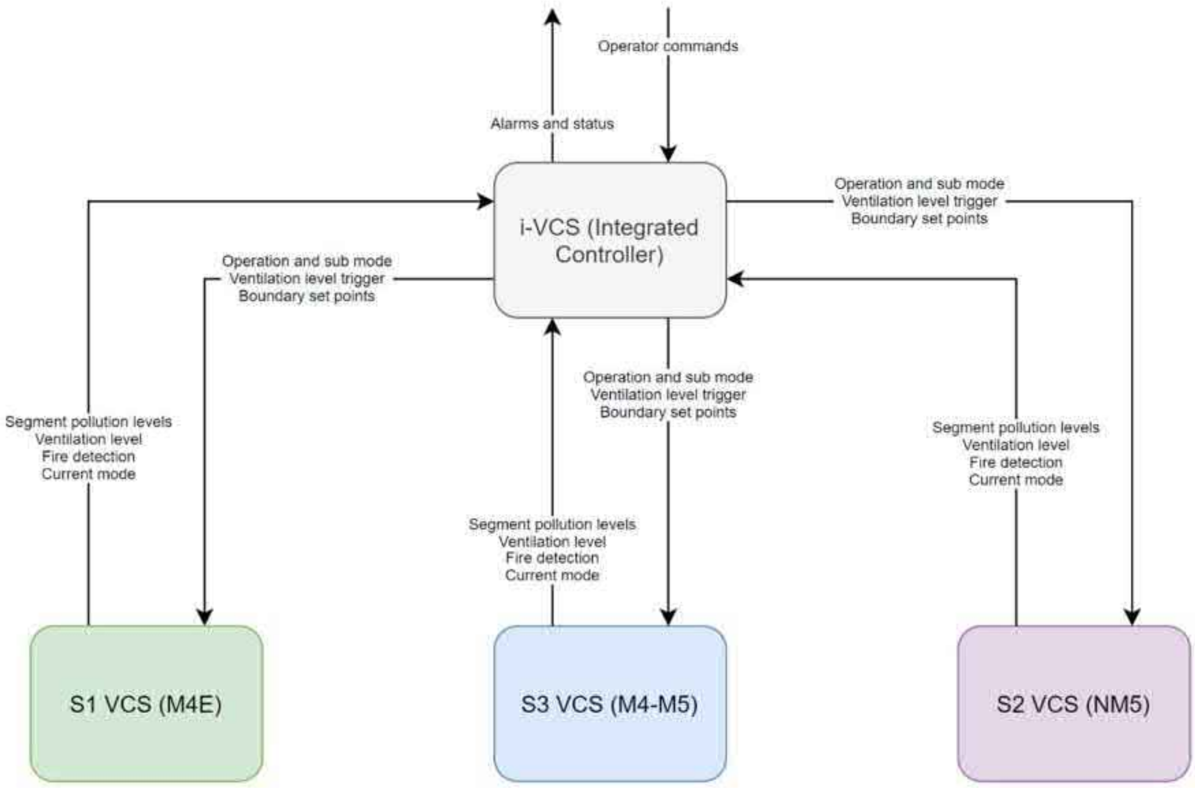
An Integrated Ventilation Control System (i-VCS) has been designed to integrate the three stage independent control systems, to provide high level monitoring and control such that all 3 stages function as an Integrated WestConnex Motorway.

Each stage of the motorway reports parameters such as length average pollution for each unique travel path, the level of ventilation currently being used for that project stage, and the location of a fire within the fire affected stage.

The i-VCS utilises this information and sends a coordinated ventilation strategy to each of the project stage control systems to control air movement and pollution within the combined network. A summary of the information exchanged between the VCS's and the i-VCS is contained in the figure below.

Control of the integrated motorway can be achieved via the IOMCS or by the separate stage VCS's operating in integrated mode.

Figure 5 – i-VCS Overview



13 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 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 ASBJV, such as Independent Certifier and TfNSW.

It is envisaged that the Asset Owner and Operator, 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 the 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 an appropriate manner with systems, subsystems, equipment and services provided by others, particularly TfNSW.

The following key elements shall be validated during the commissioning tests prior to motorway opening.

- Validation that the minimum exit velocity at the ventilation outlet;
- Validation of required airflows in the various tunnel ventilation sections as described in the Ventilation System design report;
- Calibration and validation of the performance of the air monitoring devices in measuring against the required criteria;
- Confirmation that the limits and actual values are easily visible on the OMCS and IOMCS operator screens;
- Validation that the required traffic management plans can be implemented on the OMCS and IOMCS system, and the required traffic control devices operate as expected.

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 Asset Owner and Operator and opening the Tunnel to traffic.

Dedicated testing software (JIRA) will be used to perform test executions and an associated JIRA plugin (Zephyr) will be used for defect management of software tests. JIRA will also be used as a requirements management tool and will be the mechanism to demonstrate compliance to all requirements has been satisfied. This is further described in Section 6.5 of the Testing and Commissioning Management Plan, refer to Appendix A.

14 Conclusion

This Protocol meets the requirements of conditions E13 to E17. It 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 15.

15 References

15.1 Internal References

Table 11: List of Internal Project Reference Documents

Document Reference No.	Document Title
Ventilation Technical Reports	
M4M5-JAJV-TUN-MES-ME01-RPT-0005	Tunnel Ventilation Analysis Report
M4M5-LSBJ-PRW-MES-ME02-RPT-0005	Tunnel Ventilation Plant Design Report
M4M5-LSBJ-PRW-MES-ME03-RPT-0005	Tunnel Ventilation Controls Report
M4M5-LSBJ-PRW-MES-ME02-RPT-0005 – Appendix N.1	Tunnel Ventilation Air Dispersion Modelling Report
OMCS Technical Reports	
M4M5-SICE-PRW-MES-OM01-RPT-0005	OMCS Hardware Report
M4M5-SICE-PRW-MES-OM10-RPT-0005	OMCS Software Architecture Report
M4M5-SICE-PRW-MES-OM17-RPT-0005	SIDERA Core Functionality Design Report
M4M5-SICE-PRW-MES-OM21-RPT-0005 to M4M5-SICE-PRW-MES-OM26-RPT-0005	TMCS Functionality Technical Reports
M4M5-SICE-PRW-MES-OM30-RPT-0005	PMCS Functionality – Ventilation Design Report
IOMCS Technical Reports	
M4M5-SICE-PRW-MES-OM60-RPT-0005	IOMCS Software Design Report
M4M5-SICE-PRW-MES-OM63-RPT-0005	Integrated SIDERA Core Functionality Design Report
Commissioning Documentation	
M4M5-LSBJ-PRW-MES-MP01-PLN-0003	Testing & Commissioning Management Plan
M4M5-SICE-PRW-MES-OM30-ITR-1008	OMCS PMCS Ventilation SAT Test Cases
M4M5-SICE-PRW-MES-OM63-ITR-7008	IOMCS Incident Management System I-SIT Test Cases
Emergency Response Documentation	
M4M5-LSBJ-PRW-GEN-OP01-PLN-0005	Emergency Response Plan

15.2 External References

Table 12: List of Applicable Standards and External Reference Documents

Document Reference No.	Document Title
WestConnex M4-M5 Link Project Specifications	
DPIE Conditions of Approval SSI-7485	WestConnex M4-M5 Link Infrastructure Approval
M4-M5 Link D&C Deed - Exhibit M	WestConnex M4-M5 Link Scope of Works and Technical Criteria
Asset Owner and Operator Documentation	
WOM-OP-PL-2	Incident Response Plan
WOM-OP-PR-13	Incident Response Procedure – Congestion
WOM-OP-PR-19	Incident Response Procedure – Systems Failure or Degradation
WOM-OP-PR-24	Incident Response Procedure – Air Quality

Appendices

Appendix A

Testing and Commissioning Management Plan

Appendix A. Testing and Commissioning Management Plan

Available upon request