Auckland City Rail Link

Enabling Works

Britomart Transport Centre; Fire Engineering Report

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The Fire Engineering for the C1 Enabling Works to the existing Britomart Transport Centre, for the City Rail Link (CRL) project is contained within two separate reports which have different purposes.

The Fire Engineering Brief (FEB) formed the initial stage of the regulatory approvals process for fire engineering. The FEB defined the design approach and acceptance criteria for the fire engineering design associated with the station Temporary Works within Britomart with reference to the existing consent and fire engineering design assumptions.

This Fire Engineering Report (FER) describes in more detail the fire safety measures of the existing Britomart Transport Centre, during the Temporary Works and Permanent Works. It provides the modelling and analysis to demonstrate the Performance Requirements and Acceptance Criteria have been met.

This FER report presents the results of the analysis of the existing Britomart Transport Centre for the City Rail Link (CRL) project and should be read in conjunction with the FEB which contains the fire engineering inputs. The C1 Enabling Works (which can be defined as Temporary Works and Permanent Works) are concerned only with the western end of the station, as a modification to the existing previously consented Britomart fire engineering design as prepared by Stacey Agnew Pty Ltd, dated February 2016. This documentation is concerned only with the temporary phase associated with the C1 Enabling Works, not the remainder of the CRL project. The CRL main construction works, scheduled to occur 2018 -2023, will see Britomart become a through-station as compared to a terminating station; this is to be the subject of a separate consent and Fire Engineering assessment.

Further, the new tunnel sections which form part of the Britomart Transport Centre redevelopment are addressed within the Enabling Works Albert Street C2 Tunnels Fire Engineering Report.

For the City Rail Link (CRL) project, works to the existing Britomart Transport Centre will include the creation of the new tunnels below the Chief Post Office (CPO) portion of Britomart, which will extend beneath lower Queen Street and will become the CRL lines. During these initial Temporary Works, the CPO building will be vacated and closed to the public while the new tunnels are constructed beneath. Therefore, during these works new temporary egress routes will be required from the Britomart Transport Centre platforms to replace those which are currently via the CPO building. Upon completion of the tunnels under the CPO, the CPO will be reopened; this Permanent Works configuration of the station will remain until the completion of the CRL main construction works.

The scope of works excludes any areas where there are no proposed works during the Enabling Works stage i.e. to the upper levels of the CPO (above Ground Floor), eastern end of Britomart (Britomart East), platforms, and the existing tunnel section to the east of the station.

It is noted that though this is an existing building and Section 112 of the Building Act is applicable, in general, the approach has been to demonstrate either compliance with the current NZBC, or compliance as near as reasonably practicable. With respect to means of egress from the FOH areas (Station and CPO Ground Floor) it has been demonstrated that there is not only relative improvement of performance compared to existing conditions, but also compliance to the NZBC.

Specific Fire Engineering Design has been used as the design basis for the Front-of-House areas, including the new Temporary Entrance to demonstrate compliance to New Zealand Building Code. New Back-of-House areas have been designed to comply with Acceptable Solutions C/AS5. Note, there are also a number of clarifications, proposed modifications and waivers to this Building Code Clauses which having previously been agreed in principle by the Auckland Council and MoBIE that will be applied for as part of the Building Consent process.

1 Introduction

1.1 Purpose of the Fire Engineering Report (FER)

This report documents the fire safety design for the Britomart Transport Centre during the Temporary Works and Permanent Works stages, prior to the commencement of the main CRL works.

The design has been developed to meet the project functional requirements and the acceptance criteria identified within the Temporary Works Britomart Transport Centre Fire Engineering Brief, document reference CRL-BTM-FIR-000-RPT-0005.

The Fire Engineering Report (FER), based on the agreed FEB and stakeholder consultation, develops the fire safety strategy and identifies the concept fire safety measures of the Reference Design, and details the results of the analysis and modelling to demonstrate compliance with agreed Acceptance Criteria.

A further aim of this document is to ensure that there is a consistent approach to fire and life safety for Britomart Transport Centre and the completed CRL project. The fire engineering design for these Temporary Works will reference the design assumptions as stated within the original fire engineering design for Britomart Transport Centre and design assumptions for the system wide (operational) CRL as presented within the System Wide Fire Engineering Brief, document CRL-SYW-FIR-000-MAN-0007.

The Fire Engineering Brief established the design basis, which was agreed with the relevant stakeholders as listed in Table 2. The fire engineering design and analysis has been undertaken taking into consideration the original fire engineering design strategy and the original consent for the existing Britomart Transport Centre.

The Fire Engineering Brief itself did not detail the full design analysis, and is not intended to be a stand-alone document to demonstrate that the building complies with the New Zealand Building Code. Rather, the Fire Engineering Brief defined the design methodology and acceptance criteria for the agreement of the various design stakeholders, including the New Zealand Fire Service and other approval authorities, so that the Fire Engineering Design process can proceed with greater certainty that the completed design would be acceptable to the approval authorities.

This fire engineering process follows the recommended format and procedures as detailed within the International Fire Engineering Design Guidelines and IPENZ Practice Note 22.

1.2 Legal Environment

1.2.1 Building Act 2004 and Building Regulations 1992

Under the Building Act 2004 (the “Act”) Section 17 states:

All building work must comply with the building code to the extent required by this Act, whether or not a building consent is required in respect of that building work.

Further under the Building Act 2004 (the “Act”) Section 112 “Alterations to an existing building” of the Act applies, which states:

(1) A building consent authority must not grant a building consent for the alteration of an existing building, or part of an existing building, unless the building consent authority is satisfied that, after the alteration,—

(a) the building will comply, as nearly as is reasonably practicable, with the provisions of the building code that relate to—

(i) means of escape from fire; and

(ii) access and facilities for persons with disabilities (if this is a requirement in terms of section 118); and

(b) the building will,—

(i) if it complied with the other provisions of the building code immediately before the building work began, continue to comply with those provisions; or

(ii) if it did not comply with the other provisions of the building code immediately before the building work began, continue to comply at least to the same extent as it did then comply.

(2) Despite subsection (1), a territorial authority may, by written notice to the owner of a building, allow the alteration of an existing building, or part of an existing building, without the building complying with provisions of the building code specified by the territorial authority if the territorial authority is satisfied that,—

(a) if the building were required to comply with the relevant provisions of the building code, the alteration would not take place; and

(b) the alteration will result in improvements to attributes of the building that relate to—

(i) means of escape from fire; or

(ii) access and facilities for persons with disabilities; and

(c) the improvements referred to in paragraph (b) outweigh any detriment that is likely to arise as a result of the building not complying with the relevant provisions of the building code.

Therefore the minimum requirement under the Act is that the building shall comply as near as reasonably practicable with the provisions of the Building Code which relate to:

- Means of escape from fire, and
- Access and facilities for persons with disabilities

As defined in Section 7 of the Act, means of escape includes all active and passive protection features required to warn people of fire and to assist in protecting people from the effects of fire in the course of their escape from the fire.

Areas of new works including the new Temporary Entrance, Britomart West, CPO Ground Floor must be assessed against the current New Zealand Building Code Clauses C2 – C6, to determine whether the areas comply or comply as nearly as reasonably practicable where new works would be unduly prohibitive.

The existing and unaltered areas of the station must also continue to comply with the other provisions of the Building Code to at least the same extent as before the alteration as per the original consented design, and as documented within the existing Fire Engineering Report. The existing station platform level, Britomart East and CPO building upper levels are beyond the scope of this report. It is assumed that these areas will continue to comply at least to the same extent as it did prior to the ACRL works. It is also noted that a cursory review of current conditions and a review of the previous Fire Engineering Reports, and Section 112 review in 2014, show the existing parts appear to comply with the NZBC C Clauses.

1.2.2 Design intent and method

Britomart Transport Centre is considered to be outside of the scope of the compliance documents C/AS1 – C/AS7 and C/VM2. Both C/AS4 (Acceptable Solution for Buildings with Public Access and Educational Facilities) and the Verification C/VM2 have not been written for large and complex buildings, such an underground railway station. Also C/VM2 does not appropriately cover the fire hazards associated with electric passenger trains.

The existing 2006 consent for the electrification of Britomart Transport Centre and associated Stacey Agnew Fire Engineering Report is the basis of compliance of the specific fire engineering design. As Britomart Transport Centre is an existing building it has been proposed to demonstrate compliance with the relevant Clauses of the NZBC, or as nearly as reasonably practicable. It will also be shown that there is relative improvement or compliance to the same extent as prior to the proposed works. Prior to commencement of the Temporary Works it is understood that the 2006 consent conditions have been met.

Therefore compliance of the new works and its effect on existing areas will be demonstrated by:

- Specific fire engineering design has been used as the design basis for the Front-of-House areas (station public areas).
- The Temporary Entrance is proposed to comply with the relevant Acceptable Solution (C/AS4).
- The new Back-of-House areas (including CPO Level B1) are proposed to comply with the relevant Acceptable Solutions (C/AS5).
- The CPO building Ground Level is proposed to comply with the relevant Acceptable Solution (C/AS4) as near as reasonably practicable and continue to comply with the other provisions of the building code immediately before the building work began.

Fire safety measures required to achieve compliance with the New Zealand Building Code C Clauses, to as near as reasonably practicable, as required for an alteration to an existing building are detailed in Section 4 for conditions during the Temporary Works and Section 5 for conditions associated with the Permanent Works.

1.2.3 Clarifications, Modifications, and Waivers

Proposals for clarifications, modifications and waivers to the NZBC for the CRL system wide works have been reviewed between the design team, Auckland Council and MoBIE. These have been summarised below and agreed in principle, refer Appendix L.

Table 1: Summary of requested waivers, modifications and clarifications to NZBC

Clause	Request Type	Topic
Multiple	Clarification	Classification of tunnels as *Ancillary Buildings**
C3.8	Modification	Conditions for fire service intervention. Performance requirements modified to read: "*the conditions are suitable for fire brigade intervention*."
C4.3	Waiver	Conditions for evacuation from tunnels only*
C4.3	Clarification	Smoke tenability in stations
C5.4	Clarification	Provision of fire-fighting access points
D1.3.3f(ii)	Waiver	Use of station escalators for emergency passenger egress

* Not directly applicable to the assessment of Britomart Transport Centre, listed for completeness

1.2.4 Duty of care

The emphases of the fire safety provisions of the NZBC are those of health and safety and protection of other property. These emphases do not include for amenity or protection of one's own property.

The new Health and Safety at Work Act 2015 (HSWA) came into effect on 4 April 2016 which compels persons conducting a business or undertaking to ensure, so far as is reasonably practicable (SFAIRP), that workplaces are without risks to the health and safety of any person. The CRL project fire systems, particularly in relation to operations within tunnels, have been subjected to a "So Far As Is Reasonably Practicable" risk assessment (see report Ref No: CRL-RPT-0009). This SFAIRP assessment included a risk workshop with a range of stakeholders including NZFS.

1.3 Relevant Stakeholders

The main stakeholders involved in the fire engineering process are summarised in Table 2.

Table 2: Relevant stakeholders

Organisation	Role	Representative
Auckland Council	BCA	Ed Claridge Bob Lamason
Auckland Transport	Client	Claire Booth Jones Bob Lupton Steve Hawkins Darryl Wong John Fellows
Auckland Transport	Operator	Stephen Howard Chris Dickenson
Transdev	Operator	Huw Bridges
Auckland Transport	Station Management	Ray Steele Barry Fraser
Downer	ECI Contractor	Dale Burtenshaw
KiwiRail	Operator of Northern Explorer	Carl Mills
New Zealand Fire Service	NZFS Design Review	Simon Davis
New Zealand Fire Service	NZFS Operational Requirements Review	Geoff Purcell
Jasmax / Grimshaw	Architect	Cameron Ritter Martin Walton Chris Jack
Arup	Fire Safety Engineer	Jarrod Alston Peter Johnson Lizzie Sieverts (Young)
Beca	Peer Reviewer on behalf of Auckland Council	Paul Williams

A number of stakeholder consultations have been conducted for Britomart Transport Centre during the FEB / FER process, documentation of relevant correspondence is documented in the FEB.

2 Building Description and Importance Level

2.1 Building Location and Description

This document is the Fire Engineering Report (FER) for the Temporary Works for the existing Britomart Transport Centre, preceding the City Rail Link (CRL) project. These works include the creation of the new tunnels below the Chief Post Office (CPO) which will become part of the CRL lines when Britomart becomes a through station as compared to its current use as a terminating station.

The existing Britomart Transport Centre is an underground rail station, extending below the CPO building at the western end to below Britomart Place at the Eastern end. The Platform is located on Level B2 with a concourse level (Level B1) at both the east and west ends with further connection to street level (Ground).

The location of the existing below ground site is as illustrated in Figure 1:

Figure 1: General Site Layout (source: Auckland Council GIS Viewer)

Britomart Transport Centre consists of the following building parts, refer to the attached drawings where each of these building parts are identified:

- CPO building at the western end of the platform. The CPO consists of four above ground levels; i.e. ground level, which contains existing ticketing, concourse and retail areas; plus three upper existing office floors. The CPO building in particular has heritage status that has been considered particularly with respect to surface finish requirements;

- The Glasshouse, which is linked to the CPO building, and located directly above the escalators, lifts, and open stairs down to the platform level at the western end of the station;
- The below grade intermediate circulation level B1 beneath the Glasshouse which serves as an intermediate landing level for the circulation stairs and escalators between the platform below, and ground level of the CPO above;
- The existing underpass which provides a below-grade pedestrian link between the intermediate circulation level B1 and Queen Elizabeth Square below Queen Street. Permanent closure of the underpass occurred March 2016, prior to the commencement of Temporary Works;
- Platform Level below grade which extends between the CPO building at the western end to Britomart Place at the eastern end; and
- Circulation stairs, escalators and lifts at the eastern end of the platform up to a concourse level and up to ground level within the atrium space of the Ernst & Young/Westpac Building;

2.2 Scope of Works

The Temporary Works primarily involve the creation of the tunnel sections for the new CRL lines beneath the CPO and Queen Street, in addition to altering the pedestrian circulation and egress, at the western end of the station.

As a result of the CRL Temporary Works at Britomart, a number of changes to the station's egress system will occur, which will alter the existing fire safety in the station. It is proposed to maintain the total existing aggregate egress width through all stages of the Temporary Works. Note the permanent closure of the Queen Street underpass occurred March 2016, prior to the following stages.

The Temporary Works will be completed in stages, the works are summarised as follows:

<u>Construction of the Temporary Entrance and Diversion of Services</u>:

- Construction of a new Temporary Entrance to the east of the Glasshouse serve as the main public entrance to and exit from the station while the CPO building is occupied by contractors, this is to include single storey blocks to the north and south to contain amenities e.g. ticketing area and toilets.
- All levels of the CPO building will be vacated and the ground level will be separated by contractor's hoarding from the station, resulting in a reduction in the available replacement air paths for the smoke extract system; i.e. the Glasshouse will remain as the only source of make-up air at the western end of the station. It should be noted that the contractors will establish and retain a field/site office at ground level of the CPO throughout the construction works. Fire safety for the site office are the responsibility of the constructors and are beyond the scope of this report.
- Temporary closure of the stairs and escalators at the western end of the platform level from the concourse level (Level B1) up through the Glasshouse into the CPO.
- Construction of temporary stairs from platform to concourse at Level B1 through the Glasshouse connecting to the Temporary Entrance.
- Construction of temporary staff accommodations at Level B2. These areas will be fire separated from the Front-of-House areas.
- All station egress to the western end of Britomart to be via temporary stairs through the Glasshouse and the new covered canopy.

<u>Heavy Civil Works:</u>

- Continuation of egress via temporary stairs through the Glasshouse and the new covered canopy from the western end of the station.

- Demolition of the existing pedestrian underpass beneath lower Queen Street.
- Construction of the new CRL tunnel sections below the CPO.
- Construction of new plant and accommodation space at levels B1 and B2 below the CPO
- A new combined egress and Fire Service intervention stair is to be created replacing the existing Fire Service intervention stair which will no longer provide access to the south side of the platforms after the track ways are extended upon completion of the CRL project.

Reinstatement of the CPO building

- Removal of contractor's hoarding separating the ground level of the CPO Building.
- The ground level of CPO building is to be reinstated, with new retail and ticketing services.
- Upper levels of the CPO will be re-occupied by tenants.
- The Temporary Entrance that served as the station entrance and included single storey blocks to the north and south, containing amenities e.g. ticketing area, toilets during Temporary Works is to be demolished. Note: the exact timing of the demolition of the Temporary Entrance in relation to the reinstatement of the CPO is not fully known at this time; the construcion timeline presented here is intended only to be indicative.

Prior to commencing with the Temporary Works, as noted above:

- All commuter diesel multiple units (DMU) services are to be replaced by electric multiple units (EMU) services and the Northern Explorer will no longer enter Britomart Transport Centre (Occurred January 2016).
- All works associated with the 2014 Building consent including additional conditions will be met. (Occurred June 2016)

The fire scenarios assessed within this FER differ from those documented within the existing Building Consent for the existing station, which are based on the Northern Explorer and DMU services. The EMU fire scenarios are set out within a separate document (CRL-SYW-FIR-000-RPT-0002), identifying Design Fire and Sensitivity Cases for CRL.

2.3 Excluded from Scope of Works

The proposed scope of works as noted above are required to enable the early construction works preceding the completed CRL.

The areas where no works are occurring and which are outside the scope of works of this report are shown in Figure 2:

- CPO Upper Levels such that existing escape routes, building hydrants, and automatic sprinkler systems will be retained as functional throughout the construction works; and
- Britomart Transport Centre Platforms (i.e. to the east of the current ticketing gate line); and
- Britomart East

The completion of the CRL lines will be covered by another stage of works, which is excluded from this Fire Engineering Report. Works required for this final Post-CRL Configuration are summarised as follows for information only:

- Re-configuration of the eastern end of Britomart Transport Centre
    - Platforms to be reconfigured to accommodate the CRL lines.
    - Reconfiguration of the eastern entrance and egress from the station.

No changes to these existing areas of the station are proposed within the scope of the Temporary Works, and hence they are not addressed within this FER. These items are as documented within the original fire engineering design for Britomart Transport Centre, as originally consented.

- Preparation for the opening of the CRL lines within Britomart.

  This is to be the subject of a separate consent and FEB/FER process

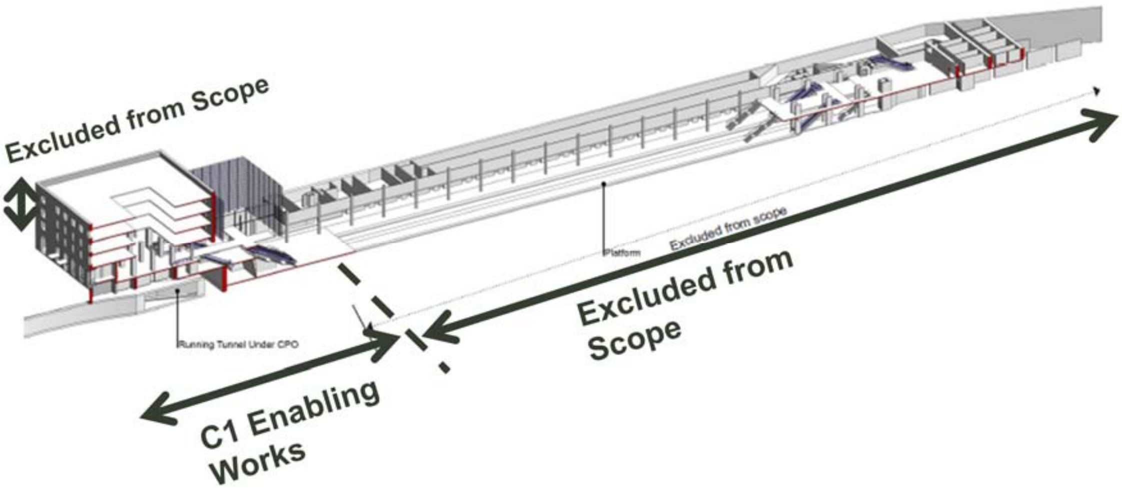


Figure 2: Britomart Transport Centre C1 Scope of Works

2.4 Building Importance Level

Due to the occupant load(s) within the station, Britomart Transport Centre is considered as having an **Importance level of 3** as defined in the NZBC Clause A3. NZBC Clause A3 defines Importance Level 3 buildings as any building where more than 300 people congregate in one area.

These buildings have increased performance requirements because they may house large numbers of people, vulnerable populations, or occupants with other risk factors, or fulfil a role of increased importance to the local community or to society in general.

2.5 Risk Groups

Although Britomart Transport Centre is subject to an Alternative Solution, some of the fire safety measures will utilise the Risk Groups of the specific areas and the relevant Acceptable Solutions.

2.5.1 Temporary Works

Table 3: Risk Groups during the Temporary Works

Location	In Scope	Risk Group	Escape Height [m]	Relevant Acceptable Solution
Britomart Transport Centre Level B2 – FOH (Platform)	Yes	CA	10.65 m	C/AS4[1]
Britomart Transport Centre Level B2 – Temp. Accommodations	Yes	WB	10.65 m	C/AS5
Britomart Transport Centre Level B2 – BOH	No[2]	WB	10.65 m	C/AS5

Location	In Scope	Risk Group	Escape Height [m]	Relevant Acceptable Solution
Britomart East	No[3]	CA / WB	< 10 m	C/AS4 C/AS5
Britomart West Concourse Level B1 – FOH	Yes	CA	< 10 m	C/AS4
Britomart West Concourse Level B1 – BOH	No[2]	WB	< 10 m	C/AS5
Glass House	Yes	CA	0 m	C/AS4
Temporary Entrance	Yes	CA	0 m	C/AS4
Temporary Entrance Amenities – North	Yes	CA	0 m	C/AS4
Temporary Entrance Amenities – South	Yes	CA/WB	0 m	C/AS4, C/AS5
CPO Ground Level	No[2]	CA	0 m	C/AS4
CPO Level 1 to 3	No[3]	WB	Up to 15.51 m	C/AS5

1. Subject to specific fire engineering design
2. Under construction/ alteration during the Temporary Works but will be including in Permanent Works Assessment
3. Subject to existing permit, no alterations to these areas during the Temporary Works.

2.5.2 Permanent Works

Table 4: Risk Groups Permanent Works

Location	In Scope	Risk Group	Escape Height [m]	Relevant Acceptable Solution
Britomart Transport Centre Level B2 – FOH (Platform)	Yes	CA	10.65 m	C/AS4[1]
Britomart Transport Centre Level B2 – BOH	Yes	WB	10.65 m	C/AS5
Britomart Transport Centre Level B2 – Temp. Accommodations	Yes	WB	10.65 m	C/AS5
Britomart East	No[2]	CA / WB	< 10 m	C/AS4 C/AS5
Britomart West Concourse Level B1 – FOH	Yes	CA	< 10 m	C/AS4[1]
Britomart West Concourse Level B1 – BOH	Yes	WB	< 10 m	C/AS5

Location	In Scope	Risk Group	Escape Height [m]	Relevant Acceptable Solution
Glass House	Yes	CA	0 m	C/AS4[1]
CPO Ground Level	Yes	CA	0 m	C/AS4[1]
CPO Level 1 to 3	No[3]	WB	Up to 15.51 m	C/AS5

1. Subject to specific fire engineering design
3. Subject to existing permit, no alterations to these areas during the Temporary Works.

2.6 Occupant Loads

Occupant loads for the PM peak and projected increases in patronage are detailed available within:

- CRL-BTM-TPP-000-RPT-0008: Contract 1 Accommodation Works Volume 5: Passenger Modelling (Detailed Design)
- CRL-BTM-TPP-000-RPT-0009: Contract 1 Permanent Works Volume 5: Passenger Modelling (Detailed Design)

For the purposes of evaluating the egress provisions within Britomart Transport Centre, the design case is a maximum occupant load of 2,600 passengers on the platform level (Level B2).

This occupant load is also consistent with the existing Building Consent and corresponding FER where, under NZBC Clause 112, a comparative assessment of the egress provisions to the consented design will be undertaken.

The current management in use plans require station operations to intervene (temporarily close the entrances) if the occupancy approaches 2600, so this limit is still relevant for the Fire Safety design.

3 Compliance with Building Code Clauses C2 - C6

While C/AS4 would be applicable to the risk group classification of Britomart Transport Centre, specific fire engineering design will be used as the design basis for Front-of-House areas within the station. The Acceptable Solutions will be used to demonstrate compliance in other areas as outlined below. The objects of Clauses C2 to C6 of the Building Code are as follows:

Building Code Clause C1 - The objectives of Clauses C2 to C6 are to:

(a) safeguard people from an unacceptable risk of injury or illness caused by fire,

(b) protect other property from damage caused by fire, and

(c) facilitate firefighting and rescue operations

With due consideration of Section 112 of the Building Act, the Fire Engineering Assessment of alterations to the existing building/ structure will address the requirements of Building Code Clauses applicable to means of escape. The Clauses C2 – C6 will be considered in full for new works (i.e. the Temporary Entrance).

The following describes the assessment methodology, alongside each of the applicable functional and performance requirement of the NZ Building Code.

Table 5: NZBC Building Code Clauses C2

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C2 – Prevention of Fire Occurring		
C2.1 Fixed appliances using controlled combustion and other fixed equipment must be designed, constructed, and installed in buildings in a way that reduces the likelihood of illness or injury due to fire occurring.	C2.2 The maximum surface temperature of combustible building materials close to fixed appliances using controlled combustion and other fixed equipment when operating at their design level must not exceed 90°C. C2.3 Fixed appliances using controlled combustion and other fixed equipment must be designed, constructed and installed so that there is a low probability of explosive or hazardous conditions occurring within any spaces in or around the building that contains the appliances.	N/A: There are no fixed appliances using controlled combustion as part of the Temporary Works.

Table 6: NZBC Building Code Clauses C3

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C3 – Fire Affecting Areas Beyond the Fire Source		
C3.1 Buildings must be designed and constructed so that there is a low probability of injury or illness to persons not in close proximity to a fire source	C3.4 (a) materials used as internal surface linings in areas of buildings must meet the performance criteria specified by the Building Code. C3.4 (b) floor surface materials in the following areas of buildings must meet the performance criteria specified by the Building Code. C3.4 (c) suspended flexible fabrics and membrane structures used in the construction of buildings must have properties resulting in a low probability of injury or illness to persons not in close proximity to a fire source. Suspended flexible fabrics used in the building construction have a flammability index of no greater than 12 when tested to AS 1530 Part 2 as per Acceptable Solutions	Materials to comply with the Performance Requirements of C3.4 (refer Table 10 below), with a minimum requirement compliant with relevant C/AS clauses. As per the Section 112 review of the CPO building in 2013, the walls, ceilings and floors are likely to comply. Compliance of the carpets are unknown. As there are no works proposed in the upper levels of the CPO it is not reasonably practicable to replace the carpet on these floors, given compliance may be achieved and the floors in question are fire sprinkler protected. In any event if any floors are refurbished in the future it is likely the floor covering will be replaced with a lining which is known to be compliant. The linings within the station are assumed to comply at the time of construction as the NZBC had the same material performance requirements as the current NZBC.

Table 6: NZBC Building Code Clauses C3

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C3 – Fire Affecting Areas Beyond the Fire Source		
C3.2 Buildings with a building height greater than 10 m where upper floors contain sleeping uses or other property must be designed and constructed so that there is a low probability of external vertical fire spread to upper floors in the building.	C3.5 Buildings must be designed and constructed so that fire does not spread more than 3.5 m vertically from the fire source over the external cladding of multi-level buildings.	N/A: The upper levels of the CPO building do not contain sleeping uses or other property.

Table 6: NZBC Building Code Clauses C3

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C3 – Fire Affecting Areas Beyond the Fire Source		
C3.3 Buildings must be designed and constructed so that there is a low probability of fire spread to other property vertically or horizontally across a relevant boundary.	C3.6 Buildings must be designed and constructed so that in the event of fire in the building the received radiation at the relevant boundary of the property does not exceed 30 kW/m^2 and at a distance of 1m beyond the relevant boundary of the property does not exceed 16 kW/m^2.	Temporary Entrance with adjacent boundaries across Tyler, Galway, and Commerce Streets complies with the relevant C/AS clauses. As per the Section 112 Review, the exterior of the station has not been altered as such the existing building is not required to be reassessed under Section 112 as it will continue to comply at least to the same extent as before the alteration. However the building is bounded by roads and it is noted that the construction is likely to comply with the relevant C/AS clauses. The new tunnel sections span across numerous boundaries below grade; such boundaries are not considered relevant boundaries as there are no air boundaries.

Table 6: NZBC Building Code Clauses C3

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C3 – Fire Affecting Areas Beyond the Fire Source		
C3.3 Buildings must be designed and constructed so that there is a low probability of fire spread to other property vertically or horizontally across a relevant boundary.	C3.7 External walls of buildings that are located closer than 1 m to the relevant boundary of the property on which the building stands must either: (a) be constructed from materials which are not combustible, or (b) for buildings in importance levels 3 and 4, be constructed from materials that, when subjected to a radiant flux of 30 kW/m^2, do not ignite for 30 minutes, or (c) for buildings in Importance Levels 1 and 2, be constructed from materials that when subjected to a flux of 30 kW/m^2, do not ignite for 15 min.	N/A: The Temporary Entrance building where above grade, are further that 1 m from adjacent boundaries, therefore the requirements of Clause C3.7 are satisfied.

Table 6: NZBC Building Code Clauses C3

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C3 – Fire Affecting Areas Beyond the Fire Source		
C3.3 Buildings must be designed and constructed so that there is a low probability of fire spread to other property vertically or horizontally across a relevant boundary.	C3.8 Firecells located within 15 m of a relevant boundary that are not protected by an automatic fire sprinkler system, and that contain a fire load greater than 20 TJ or that have a floor area greater than 5,000 m^2 must be designed and constructed so that at the time that firefighters first apply water to the fire, the maximum radiation flux at 1.5 m above the floor is no greater than 4.5 kW/m^2 and the smoke layer is not less than 2 m above the floor.	A modification to Clause C3.8 has been agreed in principle by the Auckland Council and MoBIE: Firecells located within 15 m of a relevant boundary that are not protected by an automatic fire sprinkler system, and that contain a fire load greater than 20 TJ or that have a floor area greater than 5,000 m^2 must be designed and constructed so that at the time that firefighters first apply water to the fire the conditions are suitable for fire brigade intervention Demonstration of compliance under the modification includes: Quantitative assessment (refer Appendices) demonstrates suitable conditions provided. Given the main structure of the station a comparative assessment to existing conditions has been undertaken to demonstrate performance at least to the level as before alteration.

Table 6: NZBC Building Code Clauses C3

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C3 – Fire Affecting Areas Beyond the Fire Source		
C3.3 Buildings must be designed and constructed so that there is a low probability of fire spread to other property vertically or horizontally across a relevant boundary.	C3.9 Buildings must be designed and constructed with regard to the likelihood and consequence of failure of any fire safety system intended to control fire spread.	Qualitative and Quantitative assessment in the Appendices, failure of the following systems: • Automatic sprinkler system; • Fire alarm system; • Smoke curtain; • Smoke extraction system; or • Fire and smoke rated separations, including doors

Table 7: NZBC Building Code Clauses C4

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C4 – Movement to Place of Safety		
C4.1 Buildings must be provided with: (a) effective means of giving warning of fire , and (b) visibility in escape routes complying with clause F6.	C4.3 The evacuation time must allow occupants of a building to move to a place of safety in the event of a fire so that occupants are not exposed to any of the following: (a) a fractional effective dose of carbon monoxide greater than 0.3: (b) a fractional effective dose of thermal effects greater than 0.3: (c) conditions where, due to smoke obscuration, visibility is less than 10 m except in rooms of less than 100 m^2 where visibility may fall to 5 m. C4.4 Clause C4.3 (b) and (c) do not apply where it is not possible to expose more than 1000 occupants in a firecell protected with an automatic fire sprinkler system.	A clarification of Clause 4.3, has been agreed in principle by the Auckland Council and MoBIE. Qualitative and Quantitative assessments have been conducted for the following: Temporary Entrance: In isolation complies with the relevant C/AS requirements (refer Appendices); however, it is not fire separated from Britomart Transport Centre and therefore has been assessed for completeness in the Appendices. Britomart Transport Centre during the Temporary Works: Refer Appendices Britomart Transport Centre Permanent Works: Refer Appendices. CPO Ground Level Permanent Works: In isolation complies with the relevant C/AS requirement; it is not fire separated from Britomart Transport Centre and therefore has been assessed for completeness in the Appendices. A comparative assessment to existing conditions has been undertaken to demonstrate performance at least to the level as before alteration. BOH areas comply with C/AS5 Visibility in escape routes will be provided in accordance with F6/AS1. As per the Section 112 Review, the upper levels of the CPO are not being altered; as such, the existing building is not required to be reassessed under Section 112 as it will continue to comply at least to the same extent as before alterations to levels below.

Table 7: NZBC Building Code Clauses C4

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C4 – Movement to Place of Safety		
C4.2 Buildings must be provided with means of escape to ensure that there is a low probability of occupants of those buildings being unreasonably delayed or impeded from moving to a place of safety and that those occupants will not suffer injury or illness as a result	C4.5 Means of escape to a place of safety in buildings must be designed and constructed with regard to the likelihood and consequence of failure of any fire safety systems.	Qualitative and Quantitative assessment in the Appendices, failure of the following systems: • Automatic sprinkler system; • Fire alarm system; • Smoke curtain; • Smoke extraction system; or • Fire and smoke rated separations, including doors

Table 8: NZBC Building Code Clauses C5

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C5 – Access and Safety for Firefighting Operations		
C5.1 Buildings must be designed and constructed so that there is a low probability of firefighters or other emergency services personnel being delayed in or impeded from assisting in rescue operations and performing firefighting operations.	C5.3 Buildings must be provided with access for fire service vehicles to a hard-standing from which there is an unobstructed path to the building within 20 m of (a) the firefighter access into the building, and (b) the inlets to automatic fire sprinkler systems or fire hydrant systems, where these are installed. C5.4 Access for fire service vehicles in accordance with Clause C5.3 must be provided to more than 1 side of firecells greater than 5,000 m^2 in floor area that are not protected by an automatic fire sprinkler system. C5.5 Buildings must be provided with the means to deliver water for firefighting to all parts of the building.	Provision for fire fighter operations determined in consultation with NZFS. Appropriate provisions established for NZFS access and operational requirements during the Temporary Works and Permanent Works. Refer Section 4.7 and 5.7. Qualitative and Quantitative assessment in the Appendices, failure of the following systems: • Automatic sprinkler system; • Fire alarm system; • Smoke curtain; • Smoke extraction system; or • Fire and smoke rated separations, including doors
C5.2 Buildings must be designed and constructed so that there is a low probability of illness or injury to firefighters or other emergency services personnel during rescue and firefighting operations.	C5.6 Buildings must be designed and constructed in a manner that will allow firefighters, taking into account the firefighters' personal protective equipment and standard training, to: (a) reach the floor of fire origin, (b) search the general area of fire origin, and (c) protect their means of egress	

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
	C5.7 Buildings must be provided with means of giving clear info. to enable firefighters to: (a) establish the general location of the fire, (b) identify the fire safety systems available in the building (c) establish the presence of hazardous substances or process in the building. C5.8 Means to provide access for and safety of firefighters in buildings must be designed and constructed with regard to the likelihood and consequence of failure of any fire safety systems.	

Table 9: NZBC Building Code Clauses C6

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
Building Code Clause C6 – Structural Stability		
C6.1 Structural systems in buildings must be constructed to maintain structural stability during fire so that there is: (a) a low probability of injury or illness to occupants, (b) a low probability of injury or illness to fire service personnel during rescue and firefighting operations, and (c) a low probability of direct or consequential damage to adjacent household units or other property	C6.2 Structural systems in buildings that are necessary for structural stability in fire must be designed and constructed so that they remain stable during fire and after fire when required to protect other property taking into account: (a) the fire severity, (b) any automatic fire sprinkler systems within the buildings, (c) any other active fire safety systems that affect the fire severity and its impact on structural stability, and (d) the likelihood and consequence of failure of any fire safety systems that affect the fire severity and its impact on structural stability. C6.3 Structural systems in buildings that are necessary to provide firefighters with safe access to floors for the purpose of conducting firefighting and rescue operations must be designed and constructed so that they remain stable during and after fire. C6.4 Collapse of building elements that have lesser fire	Structural systems to maintain consistency with existing systems which generally exceed current C/AS requirements, or will comply with relevant C/AS clauses. Reference Section 4.3 and 5.3. Note: As per the Section 112 Review, the existing structural systems are likely to exceed the requirements of the current NZBC.

Functional Requirement	Performance Requirement	Assessment or Statement of Compliance
	resistance must not cause the consequential collapse of elements that are required to have a higher fire resistance	

Table 10: NZBC C3.4 Surface Finish Requirements

Area of *building*	**Performance determined under conditions described in ISO 9705: 1993**	
	***Buildings* not protected with an automatic *fire* sprinkler system**	***Buildings* protected with an automatic *fire* sprinkler system**
Wall/ceiling materials in sleeping areas where care or detention is provided	Material Group Number 1-S N/A	Material Group Number 1 or 2
Wall/ceiling materials in exitways	Material Group Number 1-S	Material Group Number 1 or 2
Wall/ceiling materials in all *occupied spaces* in importance level 4 *buildings*	Material Group Number 1-S N/A	Material Group Number 1 or 2
Internal surfaces of ducts for *HVAC systems*	Material Group Number 1-S	Material Group Number 1 or 2
Ceiling materials in crowd and sleeping uses except *household units* and where care or detention is provided	Material Group Number 1-S or 2-S	Material Group Number 1 or 2
Wall materials in crowd and sleeping uses except *household units* and where care or detention is provided	Material Group Number 1-S or 2-S	Material Group Number 1, 2, or 3
Wall/ceiling materials in occupied spaces in all other locations in *buildings*, including *household units*	Material Group Number 1, 2, or 3	Material Group Number 1, 2, or 3
External surfaces of ducts for *HVAC systems*	Material Group Number 1, 2, or 3	Material Group Number 1, 2, or 3
Acoustic treatment and pipe insulation within airhandling plenums in sleeping uses	Material Group Number 1, 2, or 3	Material Group Number 1, 2, or 3
Area of *building*	**Minimum critical radiant flux when tested to ISO 9239-1: 2010**	
	***Buildings* not protected with an automatic *fire* sprinkler system**	***Buildings* protected with an automatic *fire* sprinkler system**
Sleeping areas and exitways in *buildings* where care or detention is provided	4.5 kW/m^2 N/A	2.2 kW/m^2
Exitways in all other *buildings*	2.2 kW/m^2	2.2 kW/m^2
Firecells accommodating more than 50 persons	2.2 kW/m^2	1.2 kW/m^2
All other occupied spaces except *household units*	1.2 kW/m^2	1.2 kW/m^2

4 Temporary Works Fire and Life Safety Measures

4.1 General

The Fire and Life Safety Measures required for Britomart Transport Centre during the Temporary Works to achieve compliance with the objectives of the FEB are set out in the following sections.

Britomart Transport Centre complies with the New Zealand Building Code (NZBC) with a very limited number of waiver/modifications as detailed within the FEB and as summarized herein.

Where not specifically addressed, all other items of the building solution will adopt the Acceptable Solutions requirements where appropriate, for instance, tread and riser dimensions for stairs, balustrade heights and the like.

There are no additional specifications for areas where there are no works/alterations occurring, it is understood that these areas comply with existing consent documentation and all systems are functional. These areas are:

- Britomart East,
- Britomart Transport Centre Platform (except where specified below),
- Plant and Back-of-House areas where no works are undertaken,
- CPO upper levels (Level 1 to Level 3 and Roof Plant)

The Fire and Life Safety Measures required for Britomart Transport Centre during the Temporary Works does not address construction zones within contractor's hoardings except where specified.

Figure 3: Construction Zone during the Temporary Works.

4.2 Active fire safety systems

The active fire safety systems are to be installed in accordance with the relevant New Zealand Standards, unless otherwise stated, and have been summarised in Table 11 and in Sections 4.2.1, 4.2.2 and 4.2.3. Refer Appendix A for drawings indicating fire services locations, note these are indicative; refer to the relevant fire services specifications for details.

Table 11: Temporary Works Summary Fire Protection Matrix

Location	Detection	Sprinklers	Smoke Control
Level B2			Refer Table 12
Platforms[1]	✓		
Britomart West FOH	-	-	
MSBs and Pumproom[1]	✓		
Britomart West BOH other[1,2]		✓	
Temporary Accommodations		✓	
Level B1			Refer Table 12
Britomart West FOH		✓ part	
Britomart West BOH		✓	
Britomart East FOH		✓	
Britomart East BOH		✓	
CPO Ground Level	✓	✓	Refer Table 12
CPO Upper Levels[1]		✓	Refer Table 12
Glasshouse	✓		Refer Table 12
Temporary Entrance			Refer Table 12
Forecourt		✓	
Retail Units		✓	
Temporary Blocks Ground			Refer Table 12
Comms, DB and Switchrooms	✓		
Other		✓	

Note:
1. Existing – no working being undertaken as part of this scope of works
2. Construction Zones active fire systems isolated as required
3. Other areas such as risers, voids, concealed spaces which require special consideration shall be protected in accordance with NZ 4541:2013 Section 511 except as permitted by Section 208

4.2.1 Suppression Systems

The existing Britomart Transport Centre has partial coverage automatic fire sprinkler systems which serve the CPO Building and various Back-of-House areas.

New installations will be in accordance with NZS 4541:2013; existing sprinkler systems will be maintained and modified to suit alterations. Sprinkler coverage will not be provided within some areas as specified below.

Refer to Appendix A for indicative drawings showing areas provided with automatic sprinkler protection.

Note as per NZS 4512 Clause 401.3, where sprinklers are used as thermal fire detectors, they will be provided with flow switches or other devices as necessary to provide zone indication in accordance with NZS 4512.

Temporary Entrance and Glasshouse

The Temporary Entrance will be fire sprinkler protected throughout including the temporary accommodations. Sprinklers will be installed in accordance with NZS 4541:2013.

No sprinkler coverage will be provided to the Glasshouse.

CPO

The existing fire sprinkler system is to be maintained during the Temporary Works. During the construction phase the sprinkler system on the Ground Level will be isolated so that the layout can be modified as required to suit the alterations.

Britomart Transport Centre and Back-of-House areas

Sprinkler protection of the Back-of-House areas and where installed within the public circulation areas on the concourse level (B1) will be maintained. During the Temporary Works, coverage will be modified to ensure fire sprinkler coverage is maintained or extended to designated Back-of-House areas throughout the different stages (i.e., behind the Bluestone walls, under the circulation stairs where there is potential for storage or services are being run and within Temporary Accommodations on Level B2).

4.2.2 Detection

The existing mimic panel is located at street level adjacent to the entrance into the existing Fire Service Intervention stair at the corner of Galway and Commerce Street outside of the Glasshouse at the western end of the station. The existing Fire Alarm Panel (FAP) is also provided at the eastern end of the station. Where there are system changes during the Temporary Works, Mimic Panels and FAPs will be robustly updated and indelibly marked to reflect the modified station layout.

Where required, detection will be provided in accordance with F7/AS1 requirements and NZS 4512.

As per NZS 4512 Clause 405.1.3 and 405.2.2, to reduce unwanted alarm activations, smoke detectors have been replaced by heat detectors or sprinklers (i.e., wet areas).

Note: Manual detection is facilitated by monitoring CCTV and by station staff.

Manual call points (MCP) will not be located within public accessible Front-of-House areas as these can result in repetitive malicious fire alarms. Refer to Appendix A for MCP and warden phone (WIP) locations.

Temporary Entrance and Glass House

During the Temporary Works, linear heat detection will be provided at roof level of the Glasshouse.

Within the Temporary Entrance accommodation blocks, where there is no sprinkler coverage, the areas will be separated with 2-hour fire-resistance rated construction and provided with detection.

Detection is being omitted in lieu of sprinkler coverage within the Temporary Entrance to minimize the potential for spurious alarms.

Detection is not required under the roof of the Temporary Entrance given fire sprinkler coverage and the extent of natural ventilation.

The Temporary Entrance sprinkler zone will be configured such that an alarm signal from the Temporary Entrance (including the blocks to the north and south of the forecourt) can be uniquely identified at the FAP to initiate the appropriate emergency and occupant warning response (refer Section 4.2.3 and Section 4.10.3.2).

CPO

The existing smoke detection system on Ground Level is to be isolated during the Temporary Works.

The existing system is a VESDA system, which is an aspirated smoke detection system.

Britomart Transport Centre and Back-of-House areas

Under a different scope of works, the fibre-optic heat detection system provided through the platform area has been decommissioned and replaced with a projected beam detection system as of April 2016. Automatic detection, while not a critical component of the fire life safety strategy documented in the Britomart Transport Centre Fire Engineering Report (Rev 8, Feb 2016) prepared by Stacey Agnew, provides backup to manual detection and activation of systems. Installation of the projected beam system has been termed a voluntary improvement to the original station design.

No additional detection or Manual Call Points are required within Britomart Transport Centre or the Back-of-House areas during the Temporary Works.

4.2.3 Smoke control

Temporary Entrance and Glass House

The Temporary Entrance will be provided with high level natural ventilation which will also allow for natural smoke ventilation in the event of fire. Louvres are located on the east and west façade, each façade contains 3 banks of louvres, each louvre is 3.75 m wide by 3.715 m high. The louvre type is a Colt 2UL with a discharge coefficient of 0.25, or equivalent.

The Glasshouse louvres are adjustable. During the Temporary Works, to accommodate the Temporary Entrance the louvers on the east elevation may be closed. The free area is to be maintained at a minimum of 50% of the current free area.

CPO

The CPO air path will be closed before the Temporary Works begin.

The Queens Street underpass will be permanently closed prior to the Temporary Works commencing (finalised March 2016).

Britomart Transport Centre and Back-of-House areas

The existing smoke control system over the platforms are also the environmental control fans which are operational whenever trains are running. In the event of linear heat detector actuation/projected beam detection (depending on what stage the system is replaced), the smoke control system, including smoke curtain/s, and similarly the occupant warning system is activated. Furthermore, manual override can be initiated by the operators within the Station Control Room (SCR).

The SCADA System will be modified so that the exhaust modes summarized in Table 12 are available during the Temporary Works. Mode 8, 9 and 10 should not be isolated until the fire systems within these areas are isolated and the areas are hoarded off. Changes from the current/existing ventilation modes are highlighted.

Table 12: Mode Table - Ventilation Responses during Temporary Works (highlighting indicates mode change)

Mode	Ventilation Strategy	Station Supply Fans	Station Transfer Fans	Station Exhaust Fans	Britomart Place	West Tunnel Jet Fans	Tangihua Street Exhaust Fans	East Tunnel Jet Fans
0	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
1	*Fire at Station Platforms*[1]	*Off*	*Off*	*Exhaust*[2] *100%*	*Exhaust*[2] *100%*	*2 to the East*	*Off*	*Off*
2	Fire Britomart to Tangihua	Supply	Off	Off	Off	Off	Exhaust	Off
3	Fire Tangihua to East Portal	Supply	Off	Off	Off	Off	Exhaust	Off
4	Fire in Transition Station to Britomart	Supply	Off	Off	Exhaust	Off	Exhaust	Off
5	Fire in East End B1 Public	Supply	Off	Off	Off	Off	Off	Off
6	Fire in East End B1 Back of House	Normal	Normal	Normal	Normal	Normal	Normal	Normal
7	Fire in West End B2 Back of House	Normal	Normal	Normal	Normal	Normal	Normal	Normal
~~**8**~~	~~Fire in CPO B1~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~
~~**9**~~	~~Fire in CPO Ground~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~
10	Fire in CPO Upper Levels	Off	Off	Off	Off	Off	Off	Off
11	Fire in Glasshouse	Off	Off	Off	Off	Off	Off	Off
12*	Fire in Temporary Entrance	Off	Off	Off	Off	Off	Off	Off

[1] Additional analysis verified multiple options for the ventilation scheme, refer Appendices

[2] Exhaust rates at 100 % Capacity have previously been identified by Stacey Agnew to be roughly 407 m3/s and 195 m3/s at Britomart Transport Centre and Britomart Place, respectively.

* It is recommended that changes to SCADA take place before construction of Temporary Entrance, to permit manual activation of Mode 12, due to the increased risk of fire during construction.

4.3 Structure and Fire Compartmentation

If not explicitly specified, the fire resistance ratings (FRRs) will comply with C/AS requirements. For both CA and WB risk groups these correspond to:

Table 13: NZBC C/AS4 and C/AS5 Fire resistance ratings

FRR values	Not protected by an automatic sprinkler system	Protected by an automatic sprinkler system
Life rating	60 minutes	30 minutes
Property rating	120 minutes	60 minutes

Refer Appendix A for Fire Compartmentation Drawings during the Temporary Works.

Fire rating requirements for specific areas are outlined below:

Temporary Entrance

The polycarbonate roof and associated structure need not be fire rated as per C/AS4 Clause 2.3.1 "Structural elements in a single storey building need not be fire rated if FRRs are not required for any other reason".

The following areas will be separated from adjoining areas with an FRR of 60 minutes:

- Wall of TG 153/ TG 154 bounding NZFS access to breaching inlet and Mimic Panel
- Walls bounding Electrical services i.e., Switchrooms, Communication rooms and distribution boards
- Walls bounding rubbish rooms (encompassing cleaner's stores)

External walls of the Temporary Entrance can be 100% unprotected (no FRR) as the external walls are greater than 10 m from the relevant boundaries, as shown in Figure 4

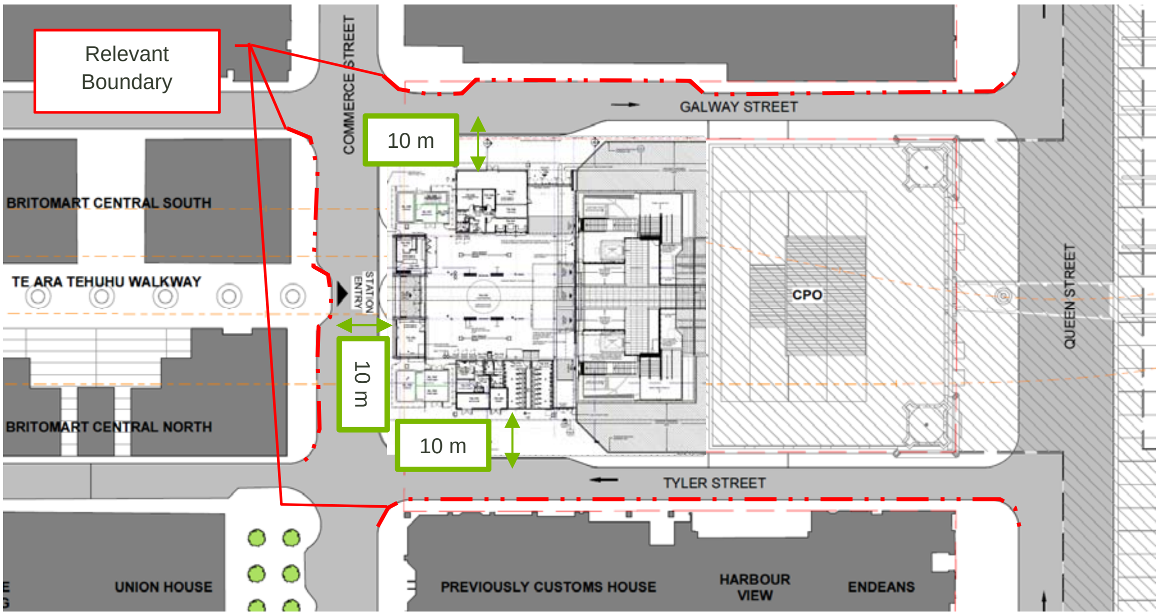


Figure 4: Separation distances of the Temporary Entrance to the Relevant Boundaries

CPO Temporary Hoardings

Separation of public/ Front-of-House and construction zones, i.e. hoarding between CPO and Glasshouse, will achieve an FRR of 120 minutes.

Where other hoardings are required between BOH and FOH areas during construction, these will achieve an FRR of 120 minutes

Separations between the station and the Temporary Works CRL Tunnels will achieve an FRR of 60 minutes, as determined in CRL-PAT-FIR-000-RPT-0001: Temporary Works Albert Street C2 Tunnels Fire Engineering Report.

Britomart Transport Centre Back-of-House

It is understood that the main structural elements of the stations are designed to have a Fire Resistance Level (FRR) of 2 hours (120 minutes). New structural elements are to have an FRR of 120 minutes.

The temporary accommodations located on Level B2 will be separated from the Front of House areas by an FRR of 120 minutes.

4.3.1 Fire Stopping and Penetrations

As per C/AS4 and C/AS5 Clause 4.4.1 Fire separations will be maintained around penetrations, and in gaps between or within building elements, by the use of fire stops. Fire stops will have an FRR of no less than that required for the fire separation within which they are installed, and will be tested in accordance with C/AS4 and C/AS5 Appendix C Clause C5.1.

Note: A fire stop for a penetration is not required to have an insulation rating if means are provided to keep combustible materials at a distance of 300 mm away from the penetration and fire stopped to prevent ignition.

The fire stopping systems will be installed in accordance with manufacturer's specifications and in the orientation for which the product is certified. All fire-rated services penetrations will have a label permanently fixed on or adjacent to them to identify the system used, the rating, the date of installation and, company name.

Ventilation ducts that pass through fire separations are to have an approved fire damper (with test latch facility and access panel where required). Where access panels are provided, the label will be positioned to be easily readable from the location of the access.

The positions of all fire sealing devices that require regular testing (e.g., fire dampers in ductwork) are to be marked on as-built drawings.

4.4 Materials Control

Materials will comply with NZBC C3.4 as reproduced below in Table 14 with dispensations for minor use materials as noted in NZBC C/AS4 and C/AS5 Clause 4.17.

Where the performance is not specified, as per Table A1 of Appendix A of C/VM2, the manufacturer will provide documentation on the product's Group Number.

The surface finish requirements do not apply to:

a) Small areas of non-conforming product within a firecell with a total aggregate surface area of not more than 5.0m²,
b) Electrical switches, outlets, cover plates and similar small discontinuous areas,
c) Pipes and cables used to distribute power or services (except as noted in Table 14),

d) Handrails and general decorative trim of any material such as architraves, skirtings and window components, including reveals, provided these do not exceed 5% of the surface area of the wall or ceiling they are part of,
e) Damp-proof courses, seals, caulking, flashings, thermal breaks and ground moisture barriers,
f) Timber joinery and structural timber building elements constructed from solid wood, glulam or laminated veneer lumber. This includes heavy timber columns, beams, portals and shear walls not more than 3.0 m wide, but does not include exposed timber panels or permanent formwork on the underside of floor/ceiling systems.
g) Individual doorsets,
h) Continuous areas of permanently installed openable wall partitions having a surface area of not more than 25% of the divided room floor area or 5.0 m², whichever is less, and
i) N/A
j) Uniformly distributed roof lights where:
    a) the total area does not exceed 15% of the ceiling area (in plan), and
    b) the minimum floor to ceiling height is not less than 6.0 m, and
    c) the roof lights achieve a Group Number not greater than 3.

Table 14: Surface Finish Requirements

Internal Surface	Area of Building	Surface Finish Requirements	
		Not protected by an automatic sprinkler system	Protected by an automatic sprinkler system
Walls and ceilings	Within Crowd Areas: All FOH areas including: • Temporary Entrance, • External walls of Temporary Accommodation walls under the polycarbonate roof • Retail fit outs • CPO Ground Floor, • Concourse/ Platforms	Material Group Number [1] 1-S or 2-S	Material Group Number 1 or 2
	Within fire or smoke separated exitways	Material Group Number 1-S	Material Group Number 1 or 2
	Within all other occupied spaces: • BOH areas that are not exitways • Internal walls of Temporary Accommodations	Material Group Number 1, 2 or 3	
Internal surfaces of ducts for HVAC systems:	All Areas	Material Group Number 1-S	Material Group Number 1 or 2
External surfaces of ducts for HVAC systems [2]	All Areas	Material Group Number 1, 2 or 3	
Floor surface materials [3,4]	Within fire or smoke separated exitways	to have a minimum critical radiant flux 2.2 kW/m^2	
	Firecells accommodating more than 50 persons • All areas except BOH areas	to have a minimum critical radiant flux 2.2 kW/m^2	minimum critical radiant flux 1.2 kW/m^2
	Within all other occupied spaces: • BOH areas	minimum critical radiant flux 1.2 kW/m^2	
Suspending flexible fabrics and membrane structures	Within all occupied spaces including exitways	Flammability index of $\leq$ 12, and Flammability index of $\leq$5 when used as underlay to roofing or exterior cladding that is exposed to view	
Cabling and wiring[5]	All areas	Low flame spread, low-smoke and low (zero) halogen	

(1) Group Number in accordance with Appendix A of C/VM2 and tested to either: ISO 5660 Part 1 and 2 or ISO 9705 or in lieu of testing refer to Table A1 of Appendix A in C/VM2
(2) Exterior requirement not applicable if duct contained within protected shaft.
(3) When tested to ISO 9239-1: 2010 or in lieu of testing refer to Table B1 of Appendix B in C/VM2
(4) Flooring requirements apply to flexible finishes such as carpets, vinyl sheets or tiles and to finished or unfinished floor surfaces.
(5) Cabling and wiring requirement part of overall ACRL strategy over and above NZBC C/AS requirements

4.4.1 Temporary Entrance

Within the temporary entrance forecourt, areas may be allocated for 'pop-up retail'. It will be necessary to constrain the size of the retail unit in order for fuel load/fuel packet sizes to conform to the nominal Temporary Entrance design fire of 3.5 MW. Accordingly, the maximum aggregate area for 'pop-up' retail is 6.3 m² with a maximum height of 2.0 m, or a maximum of 6.3 m² each (with a maximum height of 2.0 m) where separated by a clear distance of greater than 4.5 m, i.e. no seats, signs, or other combustible items within clear distance. Combustible furniture within the Temporary Entrance space is also considered a fuel packet and is required to be accounted for when considering 'pop up' retail.

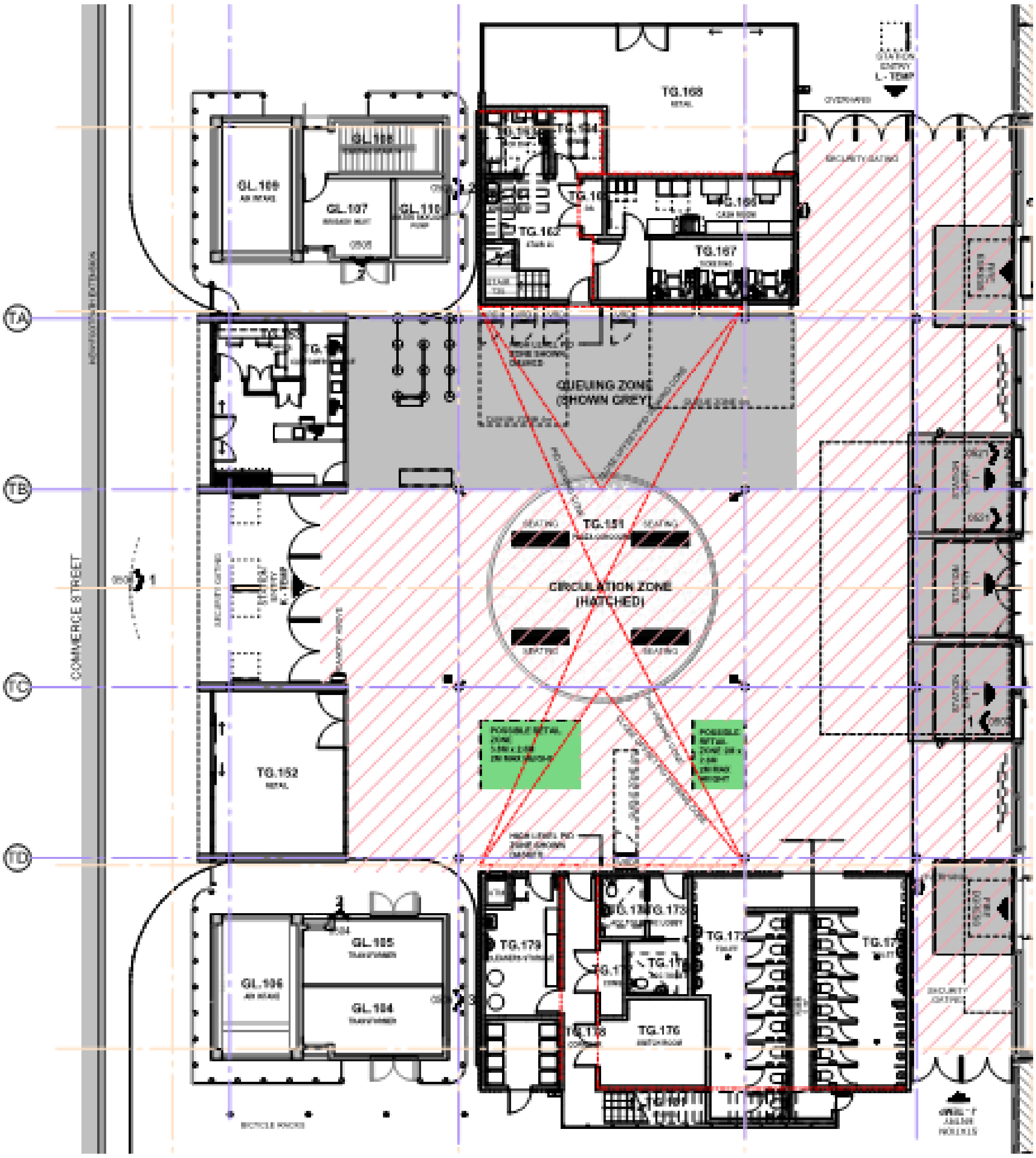


Figure 5: Permitted 'pop-up' retail zones (green) within Temporary Entrance at Ground Level.

4.4.2 Advertising materials

Advertising materials fitted to Britomart Transport Centre as a wall surface should comply with the NZBC C3.4 requirements with dispensations for minor use materials (aggregate area less than 5.0 m^2) as noted in NZBC C/AS Clause 4.17. Given the public area of Britomart is effectively one firecell, if the total aggregate area of advertising materials fitted throughout exceeds 5.0 m^2, it will need to comply with:

- NZBC Material Group Number 1, or 2 if fitted to sprinklered areas of the station; or
- NZBC Material Group Number 1S or 2S if fitted to unsprinklered areas of the station.

Other advertising materials may be provided within a non-combustible housing.

4.4.3 Furniture

NZBC requirements are not applicable to station furniture as they relate to building surface finishes.

However, consistent with the strategy identified within the System Wide FEB, for fire growth to be mitigated by the use of controlled materials in construction, it is preferred that any furniture permanently fixed to either platform, CPO, concourse, or Temporary Entrance locations at Britomart Transport Centre be constructed of non-combustible materials.

4.5 Means of Escape

4.5.1 Exit routes

Designated exits are shown on indicative drawings in Appendix A.

Temporary Entrance

The Temporary Entrance and Glasshouse will provide access and egress to Britomart West during the Temporary Works, egress paths are shown below in Figure 6.

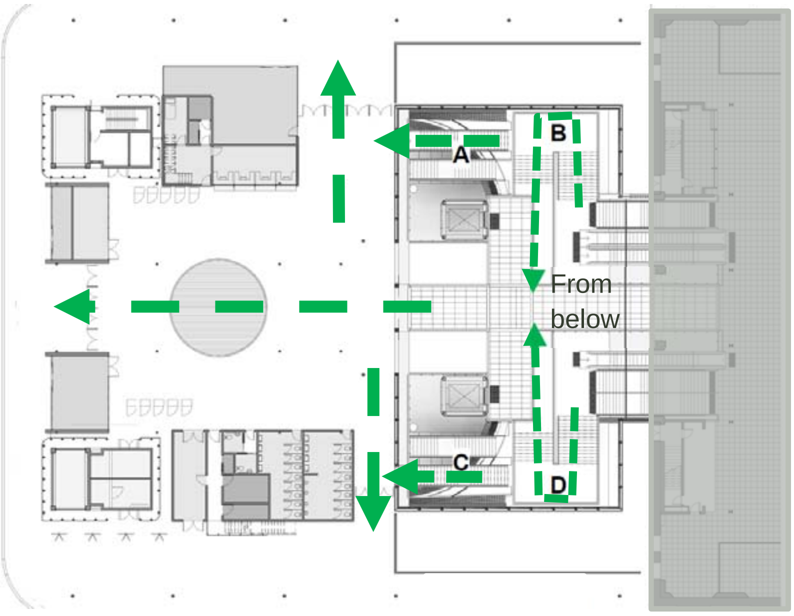


Figure 6: Egress from Britomart West at Street Level (Ground) during Temporary Works.

Locking devices (when the building is legally occupied) will:

- be clearly visible, located where such a device would be normally expected, designed to easily operate without a key or other security device, and allow the door to open in the normal manner;
- if, of an electromagnetic type, in the event of a power failure or door malfunction, either:
  - automatically switch to the unlocked (failsafe) condition, or
  - be readily opened by an alternative method satisfying the requirements of the above.
- Panic fastenings will be fitted on doors on the means of escape from fire including exitways and final exits as required.

The doors/gates of the Temporary Entrance are not required to be secured and would be retained fully open during operating hours. The doors will be secured only during non-operating hours when the building is not occupied. The design incorporates panic fastenings on a minimum of one door per each of the three exit locations from the Plaza.

Britomart Transport Centre and Back-of-House areas

Egress from the stations is via escalators and open stairs serving the platform and concourse levels (i.e., the normal access routes to and from the station) from Britomart East and Britomart West.

During the Temporary Works total egress widths will be maintained to pre Temporary Works levels from Platform Level (B2) to Concourse Level (B1) and from Concourse Level to Ground Level.

Aggregate Egress Width from the Glasshouse (doors) will correspond with aggregate egress width from the stairs from B1 to Ground. The various permanent and temporary stairs and elevators are identified in Figure 7 and Figure 8.

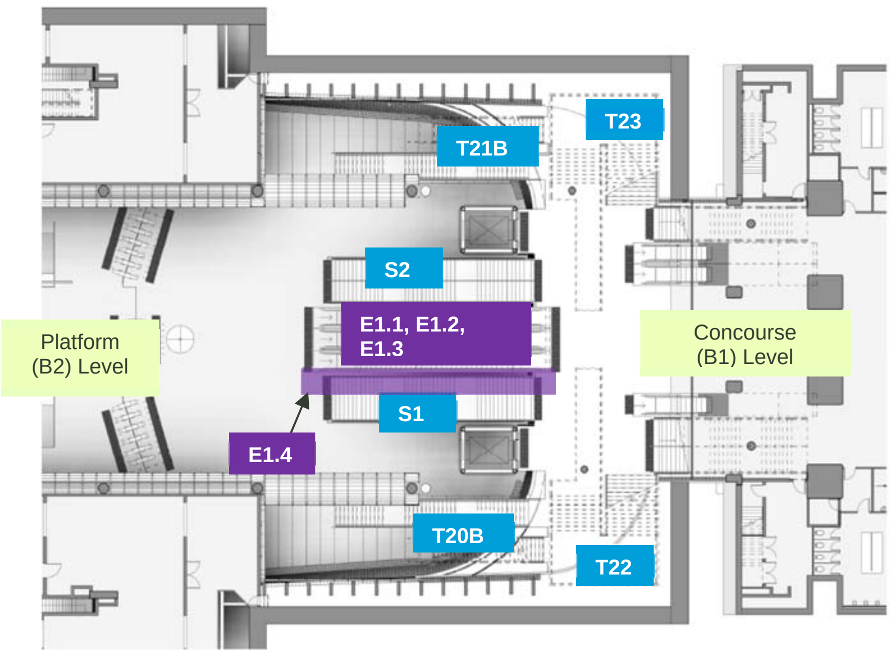


Figure 7: Temporary Works Stairs & Escalators – Platform Level (B2) to Concourse Level (B1)

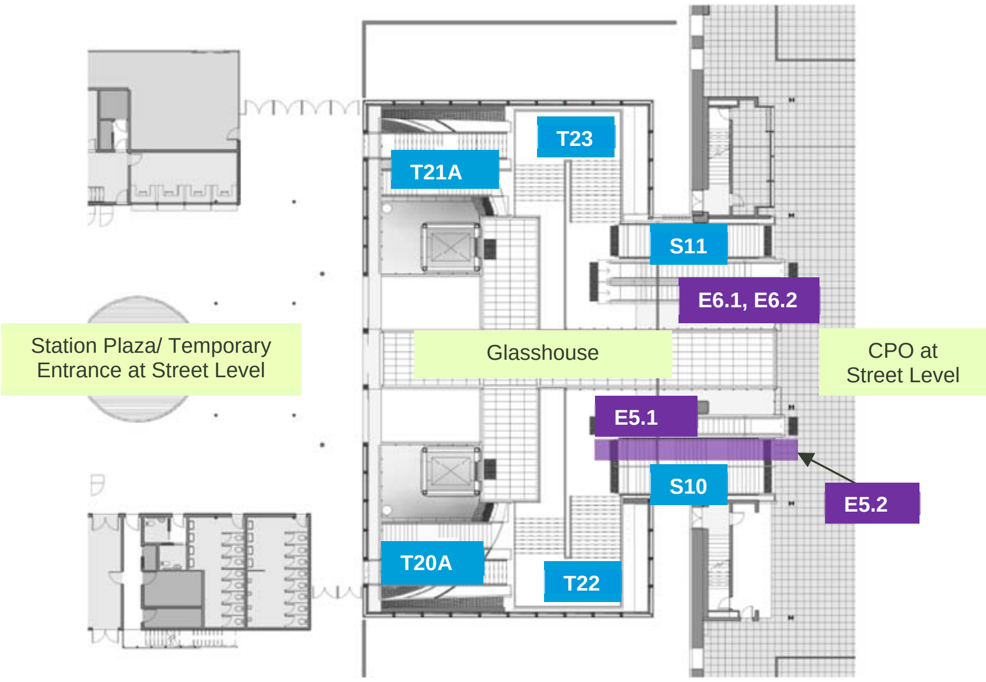


Figure 8: Temporary Works Stairs & Escalators - Concourse Level (B1) to Ground Level

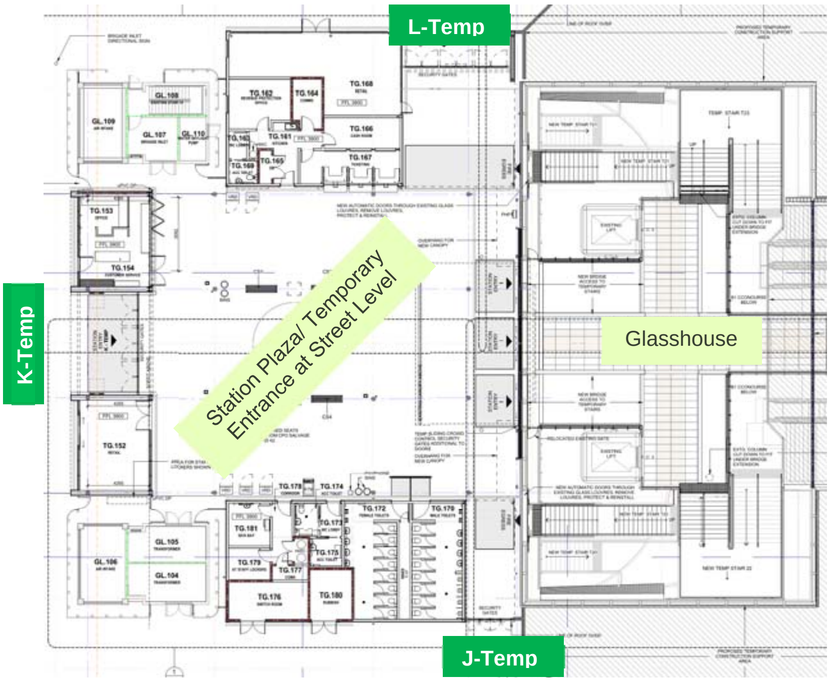


Figure 9: Temporary Works - Ground Level Temporary Entrance Final Exits

During the Temporary Works there will be various construction stages with indicative changes in egress provisions as outlined in Table 15.

Table 15: Indicative Staging

DSB Stage	PTA Phase	Description
	0	The existing configuration of Britomart West
1	A	Station plaza and street preparation B1 stone water wall demolition Existing Glasshouse entry still open Installation of temporary stairs T20 and T21 All existing Vertical Transport still operational
2	B	Construction of temporary facilities and canopy in plaza Existing Glasshouse entry point closed Installation of temporary stairs T22 and T23 All existing Vertical Transport still operational
3	C	Switch ticketing and amenities over to Temporary Accommodation during weekend closure of West entrance Install hoarding between Glasshouse & CPO
	D	CPO closed for construction and underpinning works. Stairs S10 and S11, and escalators E5.1, E6.1 and E6.2 out of service. All temporary stairs online from this point. All capacity is via temporary stairs.
	E	Installation of additional escalator E1.4 to platform level. Stair S1 and existing neighbouring escalator (E1.1) out of service to allow this.
	F	As stage D, but now with escalator E1.4 operational and stair S1 of reduced width.
	G	Revised hoarding line at B1 (constraining pedestrian flow to stair T22 and T23) to allow for reinstatement of vertical transport from B1 to CPO, including the new escalator E8
	H	CPO reopened Temporary entry and stairs dismantled New escalator E5.2 functional New escape stairs from platform level functional All west escalators upgraded to 100per/min Works on future CRL track beds (B2 level)
	I	Permanent works

4.5.2 Exit Capacity

Britomart Transport Centre

At Britomart West, the exit capacities from the station at various stage of the Temporary Works are as follows:

Table 16: Britomart West Station Exit Capacities

Level	Element	Approximate Width
Platform (B2) to Concourse (B1)	S1 Pre Stage E | Post Stage E	2.9 m | 1.7 m
	S2	2.9 m
	E1.1 – E1.3	1.0 m - Capacity 75 p/min
	E1.4 new Post Stage E	1.0 m - Capacity 100 p/min
	T20B	1.7 m
	T21B	1.7 m
	New Fire Intervention Stair (to Ground, no access from FOH B1) Post Stage H	3.2m
Concourse (B1) to Ground	E5.1, E6.1, E6.2*	1.0 m - Capacity 75 p/min
	E5.2 new Post Stage G	1.0 m - Capacity 100 p/min
	S10* Pre Stage C | Post Stage G only	2.2 m | 2.0 m
	S11*	2.2 m
	T20A	1.7 m
	T21A	1.7 m
	T22 Temporary Works | Stage G only	3.5 m | 2.0 m
	T23 Temporary Works | Stage G only	3.5 m | 2.0 m
Final Exits at Ground	J-Temp K-Temp L-Temp	2.9 m 6.6 m 6.7 m

* Not available Stage C to Stage G

The exit capacities at Britomart East remain unchanged and are outlined below in Table 17.

Table 17: Britomart East Station Exit Capacities

Level	Element	Approximate Width
Platform (B2) to Concourse (B1)	Platform 1/2: S5	1.5 m wide
	Platform 1/2: E2.1	1.3 m - Capacity 75 p/min
	Platform 3: S6	1.5 m wide
	Platform 3: E3.1	1.3 m - Capacity 75 p/min
	Platform 4/5: S7	1.5 m wide
	Platform 4/5: E4.1	1.3 m - Capacity 75 p/min
Concourse (B1) to Ground	S 12/13	2.8 m
	E7.1	1.5 m - Capacity 100 p/min
	E8.1	1.5 m - Capacity 100 p/min

4.5.3 Travel Distance

Temporary Entrance

The travel distances from the Temporary Entrance and the ancillary functions within the Temporary Entrances (single storey blocks to the North and South) are within the limits provided by C/AS4 and C/AS5.

Table 18: Temporary Entrance Travel Distance

Area	Maximum allowable Dead End Open Path	Maximum allowable Total Open Path	Actual DEOP / TOP
Temporary Entrance (FOH) - C/AS4	40 m	100 m	13 m / 32 m from Female Toilets

Britomart Transport Centre

The platform is approximately 160 m in length, the maximum travel distance from the end of the platform at Britomart West to a safe place is approximately 81 m. This is measured from the platform edge to the Glasshouse exits. There is a further distance of travel of 5 m to 35 m to outside depending on the exit from the Glasshouse and the exit from the Temporary Entrance. It has been demonstrated through ASET/RSET assessment (Appendix D) that passengers are afforded a tenable path of egress.

Britomart Transport Centre Back-of-House Areas

There are no changes to egress paths from the existing Back-of-House areas; the travel distances are understood to be within the limits provided by C/AS5.

Table 19: BOH Travel Distance

Area	Maximum allowable Dead End Open Path	Maximum allowable Total Open Path
BOH - C/AS5	50 m	120 m

Note, as per C/AS Clause 3.4.2, an open path ends either at: the start of an exitway, or a final exit, or the point where the escape route passes into an adjacent firecell on the same level (see Clause 3.7.13 which permits an open path to pass into an adjacent firecell on the same level and recommence as a new open path given a number of provisions).

4.6 Exit Signs and Emergency Lighting

Exit signs and emergency lighting are to be provided throughout in accordance with NZBC F6 and F8, and NZS 2293.1:2005 and NZS 2293.3:2005.

Existing exit signs and emergency lighting will be modified (removed and/or added) as required during the course of the Temporary Works to maintain compliant coverage. Where reasonably practicable these should be upgraded to comply with current requirements if they currently do not.

Indicative exits sign locations are shown in Appendix A as located in accordance with NZBC F8.

Indicative emergency lighting requirements are noted below; however, a suitably qualified person is to design and install the emergency lighting system.

Temporary Entrance

Emergency lighting will be provided in the following areas with a direct illuminance of no less than that specified below (as per F6/AS1 Clause1.3.1):

- Within the Temporary Entrance Plaza: a minimum 1 Lux

As per F6/AS1 Clause 1.6.1, emergency lighting must be maintained for 90 minutes.

4.7 Firefighting Provisions

4.7.1 Fire Hose Reel Systems and Fire Extinguishers

Existing fire hose reels on B2 of Britomart West will be removed and replaced with fire hydrant outlets.

Other existing fire hose reels including those situated along the platforms will be retained.

No new fire hose reels are to be installed in the Temporary Entrance.

Fire extinguishers shall be included in the Back of House areas to comply with NZS 4541 Clause 209.1, locations are to be in accordance with NZS 4503-2005.

4.7.2 Fire Hydrant System

Temporary Entrance and Glass House

During the Temporary Works, fire hydrant coverage of the Temporary Entrance will be provided via street hydrants.

CPO

During the Temporary Works, the CPO fire hydrant system which serves each of the upper levels of the CPO will be maintained. A minimum of one hydrant must be retained operational and charged at any given time throughout construction. Alternative arrangements wherein the hydrants are configured as 'dry risers' will require consultation with NZFS and Auckland Council.

Britomart Transport Centre and Back-of-House areas

The existing fire hydrant system will be maintained during the Temporary Works. Fire hydrant outlets may be moved or additional fire hydrants added as required to maintain existing coverage during the Temporary Works.

4.8 Fire Service Access

The primary Fire Service Intervention Point will remain at Britomart East (Corner of Galway Street and Britomart Place) where the fire service have protected stair access to the BTC Main Control Room (MCR).

The secondary Fire Service Intervention Point at Britomart West will also remain at the corner of Galway and Commerce Street, as shown in Figure 10. The Fire Service Intervention Point at Britomart West within the South Vent Building consists of a mimic panel as well as sprinkler and hydrant inlets.

The South Vent Building also contains the entry to protected stairs to the Platform Level (B2) only. This will remain accessible to the platform during the majority of Temporary Works (until Stage I) from which point the stair will discharge into Back-of-House areas of Platform Level (B2).

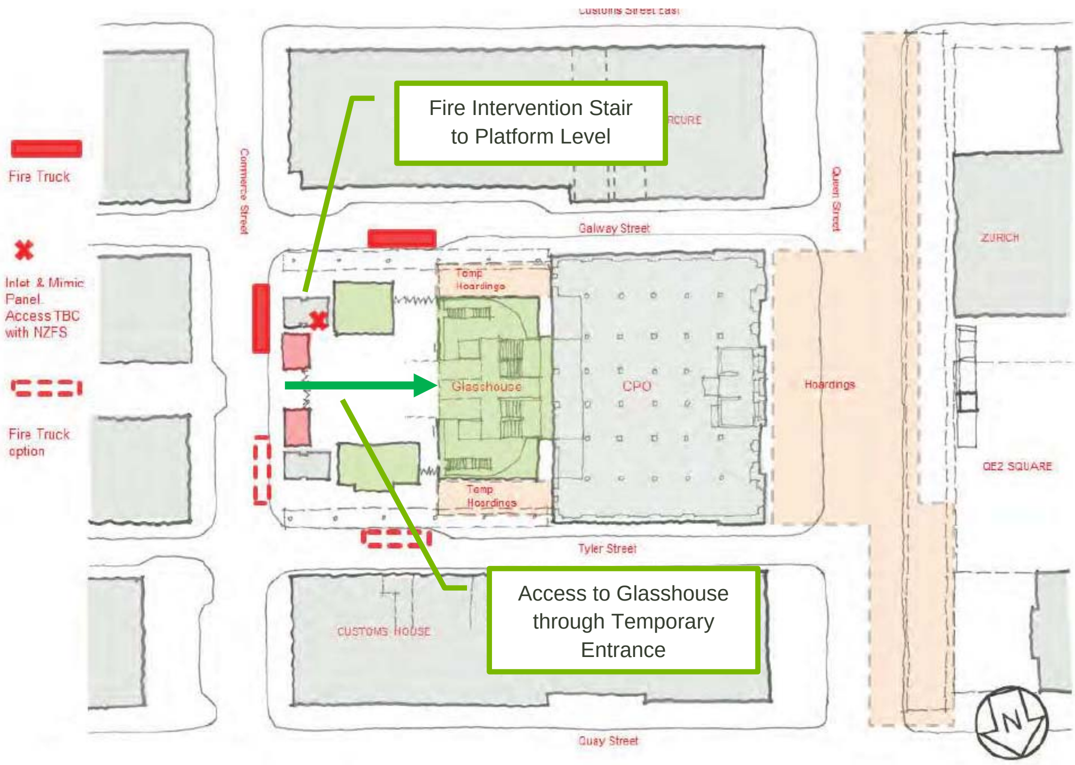


Figure 10: Fire Service access during Temporary Works

During the Temporary Works, the plaza area between the Fire Service Intervention Point and the Glasshouse will become the Temporary Entrance. Additional provisions as shown below in Figure 11 will assist NZFS personnel during the Temporary Works.

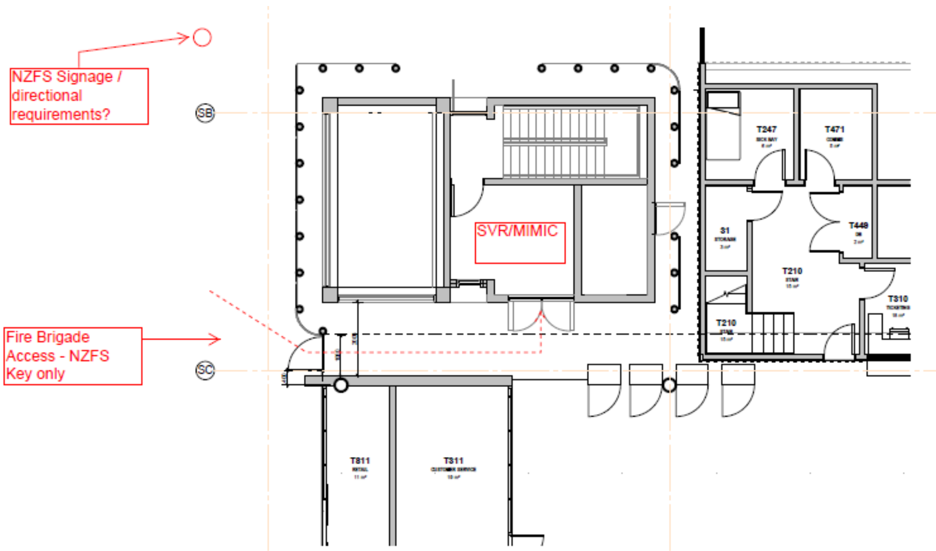


Figure 11: Temporary Fire Service access to Mimic Panel and outlets during Temporary Works

4.9 Testing and Commissioning

Following installation of the Temporary Accommodation and closure of the CPO, the fire safety systems including the Britomart ventilation system and SCADA controls will undergo concurrent 'end-to-end' tests of the system interfaces to confirm that they operate in accordance with the approved design.

The Britomart ventilation system and SCADA controls will require re-commissioning following changes to the system to ensure that appropriate flow rates are achieved by fans, and that the operational modes are activated by the appropriate fire alarm signals.

Re-commissioning and testing will focus in particular on:

- The SCADA and Occupant Warning response to new fire alarm signals originating in the Temporary Accommodations and Glasshouse
- The revised SCADA response for a fire alarm at platform level
- Air flow rates delivered by fan sets responsible for responding to station fire incidents
- Air flow rates at key locations in the station and tunnels for the various fire modes (e.g., longitudinal tunnel flow rates, flow rates in vertical transport routes)

4.10 Management in Use & Operational Requirements

4.10.1 Routine Maintenance

CCTV, PIDS and PA systems will be identified as specified systems and included in the site's compliance schedule to ensure they are routinely maintained and inspected as they are an integral part of the fire safety strategy.

The compliance schedule will be amended to include changes associated with the Temporary Works.

Schedule 1 of the Building (Specified Systems, Change the Use, and Earthquake-prone Buildings) Regulations 2005 lists the specified systems.

4.10.2 Management in Use

As part of the management in use procedure:

- AT floor staff to monitor furniture, installations and pop-up retail activities for conformance to design limitations.
    - Advertising materials will be provided within non-combustible housings.
    - Permitted retail zones within the Temporary Entrance are based on restriction of fuel load and maintaining location of zones (identified by others), as shown in Figure 5, that provide unobstructed sightlines to passenger information displays (PIDs). The maximum aggregate area for 'pop-up' retail is 6.3 m², or a maximum of 6.3 m² each where separated by a clear distance of greater than 4.5 m, i.e. no seats, signs, or other combustible items.
    - Significant increases in fuel load (temporary or permanent), e.g. art installations involving combustible materials, pop up stores etc. Are not permitted unless specifically assessed on a case by case basis.
- AT will monitor occupant loads within the station, limiting the platform population to no more than 2,600 persons. Where there are unexpected surges in occupant loads (e.g., special events, system disruptions), staff will direct occupants to appropriate exits to assist in clearing platforms and prevent additional occupants entering the platform area via shutting of ticketing gates.

4.10.3 Emergency Response

Emergency response will be modified to account for temporary changes in evacuation strategy due to the Temporary Works. There are no significant changes proposed to the existing emergency strategy, which are documented in the Emergency Response Manual (ERM).

A summary of the emergency response procedure is as follows:

- Manual detection via a Help Point or manual call point or over staff radio is generally expected to occur prior to automatic detection via detector or sprinkler.
- The Main Control Room or Station Controller will manually activate the appropriate fire systems.
- Activation of the sprinkler system will automatically initiate the fire system response associated with the fire sprinkler zone.
- Automatic detection will notify the Main Control Room/Station Controller who will utilise CCTV and staff in the vicinity of the alarm to verify the alarm. The system is provided with a 60-second delay after which it will automatically initiate the appropriate fire system response.
- The Station Controller has the ability to manually override all fire systems to force activation or to stop activation.
- In a fire event, the Station Controller has set procedures for the management of fire operations including activation of appropriate fire systems and the notification of emergency services.
  - Signals will prevent trains from entering the tunnel and platform areas. The Station Controller and CTC have control to instruct trains at platforms to depart the Station if appropriate.
  - Occupant evacuation appropriate to the fire location is directed via PA announcements and PIDs messaging.
  - SCADA response appropriate to the fire location will control exhaust and supply fans
- On automatic activation, smoke exhaust and occupant warning is activated according to the predetermined response to the specific fire event
- On manual activation, smoke exhaust and occupant warning is activated according to the predetermined response to the specific fire event or as deemed appropriate by the Station Controller.
- Platform staff are trained to carry out fire emergency procedures which include provisions for assisting occupants requiring help, manually controlling escalators, directing occupants to exits and keeping order.

4.10.3.1 Emergency Response Matrix

The following high-level Emergency Response Matrix for Britomart West fire events and is provided for illustrative purposes. It considers fire scenarios in various parts of the facility and references SCADA control modes as previously summarised in Table 12.

Table 20: Representative Britomart Transit Centre emergency response procedures

Fire Scenario	Fire at Station Platforms	Fire in West End B2 BOH	Fire in CPO B1	Fire in CPO Ground	Fire in CPO Upper Levels	Fire in Glasshouse	Fire in Temporary Entrance
Activating device							
Manual	Y	Y	Y	Y	Y	Y	Y
Detection	Y	N	*	*	-	Y	-
Sprinkler	-	Y	*	*	Y	-	Y
Platform Evacuation							
All out	Y	Y	*	*	*	-	-
Direct towards Britomart East	-	-	*	*	*	Y	Y
Direct towards Britomart West	-	-	*	*	*	-	-
Other Systems							
SCADA Mode	1	7	*	*	*	11	12
Air Handling Systems	Off	Off	*	*	*	Off	Off
Escalators Britomart East	Up	Up	*	*	*	Up	Up
Escalators Britomart West	Up	Up	*	*	*	Down	Down
Smoke Curtain Deploys	Y	-	*	*	*	-	-

* Area under construction, CPO Ground Level fire systems isolated; manual notification of fire event and manual activation of other fire systems only; discretion of Station Controller depending on size of fire at time of discovery. The CPO areas are fire separated from the station during the Temporary Works

4.10.3.2 Staff Response/ Occupant Warning

The existing consent documentation and FER outlines the occupant warning requirements which have been reproduced in part:

> *"Staff at the MCR are trained to manage the evacuation of the station. A mimic fire indicator panel (FIP) is located within the MCR for BTC staff use.*
>
> *The station PA system is used to broadcast evacuation messages to passengers. The PA system can broadcast live or pre-recorded evacuation messages. The PA system has an uninterruptible power supply (UPS) to ensure its continued operations during a power outage.*
>
> *To provide warning to people in Back-of-House areas where high ambient noise levels are present, visual signalling in conjunction with audible sounders is used.*
>
> *The passenger information display system (PIDS) that is installed throughout the station notifies occupants to evacuate by the nearest exit. The PIDS system is able to display messages alerting occupants to an emergency and indicating that evacuation should occur. In an emergency, the SCADA system takes control of the PIDS away from the train information function, to display evacuation messaging as described in the O&M manual.*
>
> *Various PIDS messages can be displayed as a flashing message. The choice of message depends on the nominated direction of egress."*

PID messages will be altered during Temporary Works to:

- Remove references to evacuation through the Queens Street underpass (will be completed before the Temporary Works commence),

- Remove references to evacuation through the CPO, and
- Add additional messages to direct occupants to Britomart East exits in the event of an emergency in the Temporary Entrance, Britomart West Concourse or Glasshouse.

The Emergency Response Manual (ERM) with staff response will also be altered to:

- Direct occupants to the Britomart East exits in the event of an emergency event within the Temporary Entrance.

4.10.3.3 Persons Requiring Assistance

The strategy for the safe evacuation of persons requiring assistance requires modification. Per the existing consent and FER:

> *"Lifts will be available at the each end of the platforms for the assisted evacuation of disabled persons if required. For evacuation at the eastern ends, BTC staff may be required to manage any assisted evacuation as there is only one lift per platform at that end.*
>
> *Occupants who are deaf can be visually warned via the PIDS. Occupants who are blind may need to be assisted by BTC staff or other occupants.*
>
> *The emergency response manual ("ERM")…for the station requires designated staff members to aid persons requiring assistance, including children, disabled, ambulant disabled and elderly persons, by directing them up escalators and stairways.*
>
> *Escalators can be used as part of a managed system for occupants requiring assistance. This practice has been adopted in many countries as people requiring assistance can be helped on and off escalators by staff members. Wheelchair-bound occupants can be assisted onto the escalators and, provided they are appropriately supported, can use them to escape. The BTC escalators are designed with a longer horizontal entry and run-off length of three steps, in lieu of the normal two. This improves escalator safety during normal and emergency operations.*
>
> *For the lifts to be used for managed evacuation, staff will be required to override the lift operations. As part of the ERM, staff may utilise the lifts for disabled evacuation, if it is safe to do so"*

During the Temporary Works, use of escalators and/or elevators at the east of the station in a managed approach as described in the existing consent FER remains possible. However, at the west end of the station, evacuation can only be completed by stair or through managed use of lifts. Evacuation procedures for mobility impaired persons will need to be updated within the ERM for the Temporary Works conditions.

5 Permanent Works Fire and Life Safety Measures

5.1 General

The fire safety measures required for Britomart Transport Centre Permanent Works to achieve compliance with the objectives of the FEB are set out in the following sections.

Britomart Transport Centre complies with the New Zealand Building Code (NZBC) with a very limited number of waiver/modifications as detailed within the FEB.

Where not specifically addressed all other items of the building solution will adopt the Acceptable Solutions requirements where appropriate, for instance, tread and riser dimensions for stairs, balustrade heights and the like.

There are no additional specifications for areas where there are no works/alterations occurring; it is understood that these areas comply with existing consent documentation and all systems are functional. These areas are:

- Britomart East,
- Britomart Transport Centre Platform (except where specified below),
- Plant and Back-of-House areas where no works are undertaken,
- CPO upper levels (Level 1 to Level 3 and Roof Plant)

5.2 Active fire safety systems

The active fire safety systems are to be installed in accordance with the relevant New Zealand Standards, unless otherwise stated, and have been summarised at a high level in Table 21 and in Sections 5.2.1, 5.2.2, and 5.2.3. Refer Appendix A for drawings indicating fire services locations. Note, these are indicative only; refer to the relevant fire services specifications for details.

5.2.1 Suppression Systems

The existing Britomart Transport Centre has partial coverage automatic fire sprinkler system which serves the CPO Building and various Back-of-House areas.

New installations will be in accordance with NZS 4541:2013, existing sprinkler systems will be maintained and modified to suit alterations. Sprinkler coverage will not be provided within some areas as specified below.

Note, as per NZS 4512 Clause 401.3, where sprinklers are used as thermal fire detectors, they will be provided with flow switches or other devices as necessary to provide zone indication in accordance with NZS 4512.

Table 21: Permanent Works Summary Fire Protection Matrix

Location	Detection	Suppression System (Sprinklers unless otherwise specified)	Smoke Control
Level B2			Refer Table 22
Platforms[1]	✓		
Britomart West FOH	-	-	
Temporary Accommodations		✓	
Sump pump control room, OHLE, Comms, DB, LV MSBs and Pumproom[1]	✓		
Signal Equipment Room	✓	Gaseous suppression	
Britomart West BOH other[1,2]		✓	
Level B1			Refer Table 22
Britomart West FOH		✓ part	
HV Transformer Rooms, HV Switch Rooms, LV Switch Rooms, UPS Room, Battery Room, BMS, 3rd Party Utilities	✓		
Communication Equipment Room	✓	Gaseous suppression	
Britomart West BOH Other		✓	
Britomart East FOH		✓	
Britomart East BOH		✓	
CPO Ground Level	✓	✓	Refer Table 22
CPO Upper Levels[1]		✓	Refer Table 22
Glasshouse	✓		Refer Table 22

Note:
1. Existing – no working being undertaken as part of this scope of works
2. Construction Zones active fire systems isolated as required
3. Other areas such as risers, voids, concealed spaces which require special consideration shall be protected in accordance with NZ 4541:2013 Section 511 except as permitted by Section 208

CPO

The existing fire sprinkler system is to be maintained and modified as required to suit alterations.

The ceiling cavity of the Ground level of the CPO is not currently sprinkler protected. The conditions within the ceiling cavity between the Ground Level ceiling and the floor above is to be investigated during the CPO works. It is not required to be retro-fitted with sprinklers unless there is a significant increase in fuel load (i.e., the introduction of bundled cables), as the extent of works within the ceiling space will be minimal (passing wires through) and the cost to install sprinklers in the space would be disproportionately onerous given the heritage nature of the ceiling requiring deconstruction of the floor. Furthermore, compliance will remain to the same extent as prior to alterations.

Britomart Transport Centre and Back-of-House areas

Sprinkler protection of the public circulation areas on the concourse level (B1) will be maintained at their current levels. The following Front-of-House areas have no sprinkler protection:

- platforms
- concourse circulation spaces save for limited areas at the level B1 concourse
- above circulation stairs and escalators
- escalators, except pits

Britomart Back-of-House areas also refers to new Back-of-House areas that were previously referred to as CPO B1 (i.e., pre Temporary Works).

All Back-of-House areas (existing and new) will be fire sprinkler protected unless specifically identified below. Where an alternative fire suppression measure or detection is proposed, these areas are to be fire separated with 2-hour fire-resistance rated construction from other areas of the station.

Room	Fire protection measures
HV Transformer Rooms	Detection only
HV Switch Rooms	Detection only
LV Switch Rooms	Detection only
Communication Equipment Room	Gas suppression
UPS Room	Detection only
Battery Room	Detection only
Signal Equipment Room	Gas suppression
Other rooms containing equipment sensitive to water (comms, BMS, 3rd Party Utilities, MSB, etc.)	Detection only

5.2.2 Detection

The existing fire alarm panel is provided at the eastern end of the station. The existing mimic panel is located adjacent to street level at the entrance into the existing Fire Service intervention stair, corner of Galway and Commerce Street outside of the Glasshouse, at the western end of the station.

A new mimic panel will be located within the vicinity of the new Fire Intervention Stair in the North East corner of the CPO Ground Level (refer Section 5.8).

Permanent Works system changes will be robustly and indelibly incorporated into Mimic Panels and FAPs.

Where required, detection will be provided in accordance with F7/AS1 requirements and NZS 4512.

As per NZS 4512 Clause 405.1.3 and 405.2.2, to reduce unwanted alarm activations, smoke detectors may be replaced by heat detectors or sprinklers.

Note: Manual detection is facilitated by monitoring CCTV and by station staff.

Manual call points will not be located within public accessible/Front-of-House areas as these can result in repetitive malicious fire alarms. Refer Appendix A for MCP and WIP locations.

Temporary Entrance and Glass House

Permanent Works, the linear heat detection will be removed from the Glasshouse.

CPO

The existing smoke detection system is to be reinstated. The existing system is a VESDA system which is an aspirated smoke detection system.

The CPO FAP will be relocated or replaced within Level B1 and positioned in a location approved by NZFS.

WIPs will be located within staff areas ticketing areas, as indicated in Appendix A.

Britomart Transport Centre and Back-of-House Areas

No additional detection or Manual Call Points are required within the Front-of-House areas of Britomart Transport Centre.

Within the Back-of-House areas where there is no sprinkler coverage, the areas will be isolated by 2-hour fire-resistance rated construction and provided with detection (including areas provided with gas suppression systems). No additional detection is required where there is sprinkler coverage with appropriately located flow switches or where there is detection associated with gaseous suppression systems.

MCP coverage compliant with C/AS requirements will be provided to the new/altered Back-of-House areas on Level B2 and Level B1.

5.2.3 Smoke control

Glass House

Following completion of the Temporary Works, the Glasshouse will be returned to its pre Temporary Works configuration; i.e. the louvers will be reset to their current open areas and the temporary door penetrations will be reclosed.

CPO

The CPO Ground Level will re-open Permanent Works. There is no active smoke exhaust system within the CPO.

There is existing Type 9 smoke control in the air handling systems as required per C/AS4 and C/AS5; this will be maintained and modified as required to suit alterations.

The relevant air handling systems will shut down on local alarm and all air handling systems will shut down on General Fire Alarm except:

- Minor systems (openings not exceeding 0.1 m^2), or
- Air handling systems servicing UPS rooms to shut down on local alarm only.

Britomart Transport Centre

The existing smoke control systems over the platforms are also the environmental control fans which may be operational when trains are running. In the event of projected beam detection, the smoke control system including smoke curtains (and the occupant warning system) is activated. Manual override can be initiated by the operators within the Main Control Room (MCR).

The SCADA System will be modified to account for changes in proposed ventilation modes considering available air paths. Ventilation modes isolated during the Temporary Works are to be re-instated and the additional Temporary Works modes (11 and 12) deleted.

Table 22 summarizes ventilation modes Permanent Works. Changes from the current existing modes or modes introduced during Temporary Works are highlighted.

Table 22: Mode Table - Ventilation Responses Permanent Works (highlighting indicates mode change)

Mode	Ventilation Strategy	Station Supply Fans	Station Transfer Fans	Station Exhaust Fans	Britomart Place	West Tunnel Jet Fans	Tangihua Street Exhaust Fans	East Tunnel Jet Fans
0	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
1	Fire at Station Platforms[1]	Off	Off	Exhaust 100%	Off	Off	Off	Off
2	Fire Britomart to Tangihua	Supply	Off	Off	Off	Off	Exhaust	Off
3	Fire Tangihua to East Portal	Supply	Off	Off	Off	Off	Exhaust	Off
4	Fire in Transition Station to Britomart	Supply	Off	Off	Exhaust	Off	Exhaust	Off
5	Fire in East End B1 Public	Supply	Off	Off	Off	Off	Off	Off
6	Fire in East End B1 Back of House	Normal	Normal	Normal	Normal	Normal	Normal	Normal
7	Fire in West End B2 Back of House	Normal	Normal	Normal	Normal	Normal	Normal	Normal
8	Fire in West End B1 Back of House	Off	Off	Off	Off	Off	Off	Off
9	Fire in CPO Ground	Off	Off	Off	Off	Off	Off	Off
10	Fire in CPO Upper Levels	Off	Off	Off	Off	Off	Off	Off
~~**11**~~	~~Fire in Glasshouse~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~
~~**12**~~	~~Fire in Temporary Entrance~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~	~~Off~~

[1] Alternative ventilation scheme permissible subject to additional analysis verifying performance of the scheme against assessment in the Appendices

Britomart Back-of-House Areas

There will be Type 9 smoke control in the air handling systems, as called for by C/AS5 and will comply with AS/NZS 1668: Part 1 and interface with the automatic detection system and fire sprinkler system installed.

The relevant air handling systems will shut down on local alarm and all air handling systems will shut down on General Fire Alarm except:

- Minor systems (openings not exceeding 0.1 m²), or
- Air handling systems servicing UPS rooms to shut down on local alarm only.

5.3 Structure and Fire Compartmentation

If not explicitly specified, the FRRs will comply with C/AS requirements. For both CA and WB risk groups these correspond to:

Table 23: NZBC C/AS4 and C/AS5 Fire resistance ratings

FRR values	Not protected by an automatic sprinkler system	Protected by an automatic sprinkler system
Life rating	60 minutes	30 minutes
Property rating	120 minutes	60 minutes

Refer Appendix A for Fire Compartmentation Drawings during Permanent Works.

Fire rating requirements for specific areas are outlined below:

CPO

Existing construction of the CPO (circa 1909) is solid masonry construction.

Existing fire compartmentation will be retained as existing:

- Previous upgrade works added 30 minute FRRs to the egress stairs, service risers and the like[1].
- Per existing conditions documentation, the existing ground floor ceiling appears to achieve an FRR of 120 minutes

Additional fire separation/compartmentation will consist of:

- Fire separation between the fire intervention stair and other stairs will achieve an FRR of 120 minutes.
- Fire separation of the fire intervention stair from all other adjoining areas will achieve an FRR of 120 minutes.
- Service Risers at Ground Level will achieve an FRR of 60 minutes.
- Back-of-House areas will be fire separated from Front-of-House areas by an FRR of 60 minutes, except for the ticketing office/window

Britomart Transport Centre and Back-of-House areas

It is understood that the main structural elements of the stations are designed to have a Fire Resistance Rating (FRR) of 2 hours (120 minutes). New structural elements are to achieve have an FRR of 120 minutes.

Fire Separation will achieve an FRR of 60 minutes in the following areas

- Between sprinkler protected areas and areas fitted with gas suppression
- Between the station and the Temporary Works CRL Tunnels
- Walls bounding the Back-of-House corridors on B1
- Level B1 Back-of-House corridor subdivisions

Fire separation will achieve an FRR of 120 minutes in the following areas:

- Between Front-of-House and Back-of-House areas including the Bluestone wall
- Between Back-of-House areas and the new tunnels

[1] Section 112 Report

- Between front of house and temporary accommodations located on Level B2
- Between sprinkler protected and non-sprinklered areas within the Back-of-House
- Bounding the Fire Intervention Stair
- Existing fire separations to be retained
- Bounding 3rd Party Utilities (not sprinkler protected).

5.3.1 Fire Stopping and Penetrations

As per C/AS4 and C/AS5 Clause 4.4.1 Fire separations will be maintained around penetrations, and in gaps between or within building elements, by the use of fire stopping. Fire stops will have an FRR of no less than that required for the fire separation within which they are installed, and will be tested in accordance with C/AS4 and C/AS5 Appendix C Clause C5.1.

Note: A fire stop for a penetration is not required to have an insulation rating if means are provided to keep combustible materials at a distance of 300 mm away from the penetration and fire stopped to prevent ignition.

The fire stopping systems will be installed in accordance with manufacturer's specifications and in the orientation for which the product is certified. All fire-rated services penetrations will have a label permanently fixed on or adjacent to them to identify the system used, the rating, the date of installation and company name.

Ventilation ducts that pass through fire separations are to have an approved fire damper (with test latch facility and access panel where required). Where access panels are provided, the label will be positioned to be easily readable from the location of the access.

The positions of all fire sealing devices that require regular testing (e.g., fire dampers in ductwork) are to be marked on as-built drawings.

5.4 Materials Control

Materials will comply with NZBC C3.4 as reproduced below in Table 24 with dispensations for minor use materials as noted in NZBC C/AS4 and C/AS5 Clause 4.17.

Where the performance is not specified, as per Table A1 of Appendix A of C/VM2, the manufacturer will provide documentation on the product's Group Number.

The surface finish requirements do not apply to:

a) Small areas of non-conforming product within a firecell with a total aggregate surface area of not more than 5.0m²,
b) Electrical switches, outlets, cover plates and similar small discontinuous areas,
c) Pipes and cables used to distribute power or services (except as modified in Table 24),
d) Handrails and general decorative trim of any material such as architraves, skirtings and window components, including reveals, provided these do not exceed 5% of the surface area of the wall or ceiling they are part of,
e) Damp-proof courses, seals, caulking, flashings, thermal breaks and ground moisture barriers,
f) Timber joinery and structural timber building elements constructed from solid wood, glulam or laminated veneer lumber. This includes heavy timber columns, beams, portals and shear walls not more than 3.0 m wide, but does not include exposed timber panels or permanent formwork on the underside of floor/ceiling systems.
g) Individual doorsets,
h) Continuous areas of permanently installed openable wall partitions having a surface area of not more than 25% of the divided room floor area or 5.0 m², whichever is less, and

i) N/A

j) Uniformly distributed roof lights where:

   a) the total area does not exceed 15% of the ceiling area (in plan), and

   b) the minimum floor to ceiling height is not less than 6.0 m, and

   c) the roof lights achieve a Group Number not greater than 3.

Table 24: Surface Finish Requirements

Internal Surface	Area of Building	Surface Finish Requirements	
		Not protected by an automatic sprinkler system	Protected by an automatic sprinkler system
Walls and ceilings	Within Crowd Areas: All FOH areas including: • CPO Ground Floor[5], • Concourse/ Platforms	Material Group Number [1] 1-S or 2-S	Material Group Number 1 or 2
	Within fire or smoke separated exitways	Material Group Number 1-S	Material Group Number 1 or 2
	Within all other occupied spaces: • Back-of-house areas that are not exitways	Material Group Number 1, 2 or 3	
Internal surfaces of ducts for HVAC systems:	All Areas	Material Group Number 1-S	Material Group Number 1 or 2
External surfaces of ducts for HVAC systems [2]	All Areas	Material Group Number 1, 2 or 3	
Floor surface materials [3,4]	Within fire or smoke separated exitways	to have a minimum critical radiant flux 2.2 kW/m^2	
	Firecells accommodating more than 50 persons • All areas except Back-of-House areas	to have a minimum critical radiant flux 2.2 kW/m^2	minimum critical radiant flux 1.2 kW/m^2
	Within all other occupied spaces: • Back-of-house areas	minimum critical radiant flux 1.2 kW/m^2	
Suspending flexible fabrics and membrane structures	Within all occupied spaces including exitways	Flammability index of ≤ 12, and Flammability index of ≤5 when used as underlay to roofing or exterior cladding that is exposed to view	
Wiring and cabling	All Areas	AS/NZS 3000 (low-smoke; halogen free)	

(1) Group Number in accordance with Appendix A of C/VM2 and tested to either: ISO 5660 Part 1 and 2 or ISO 9705, or in lieu of testing refer to Table A1 of Appendix A in C/VM2

(2) Exterior requirement not applicable if duct contained within protected shaft.

(3) When tested to ISO 9239-1: 2010 or in lieu of testing refer to Table B1 of Appendix B in C/VM2

(4) Flooring requirements apply to flexible finishes such as carpets, vinyl sheets or tiles and to finished or unfinished floor surfaces.

(5) Any existing finishes within the CPO which are proposed to be retained are likely to comply with the current C/AS requirements as noted in the 2013 Section 112

5.4.1 Advertising materials

Advertising materials fitted to Britomart Transport Centre as a wall surface should comply with the NZBC C3.4 requirements with dispensations for minor use materials (aggregate area less than 5.0 m^2) as noted in NZBC C/AS Clause 4.17. Given the public area of Britomart is effectively one firecell, if the total aggregate area of advertising materials fitted throughout exceeds 5.0 m^2, it will need to comply with:

- NZBC Material Group Number 1, or 2 if fitted to sprinklered areas of the station; or
- NZBC Material Group Number 1S or 2S if fitted to unsprinklered areas of the station.

Other advertising materials may be provided within a non-combustible housing.

5.4.2 Furniture

NZBC requirements are not applicable to station furniture as they relate to building surface finishes.

However, consistent with the strategy identified within the system-wide FEB, for fire growth to be mitigated by the use of controlled materials in construction, it is preferred that any furniture permanently fixed to either platform, CPO, or concourse locations at Britomart Transport Centre is constructed of non-combustible materials.

5.5 Means of Escape

5.5.1 Exit routes

Designated exits are shown in Appendix A.

Glass House and CPO

The Glasshouse and CPO will provide access and egress to Britomart West Permanent Works; egress paths are shown below in Figure 12.

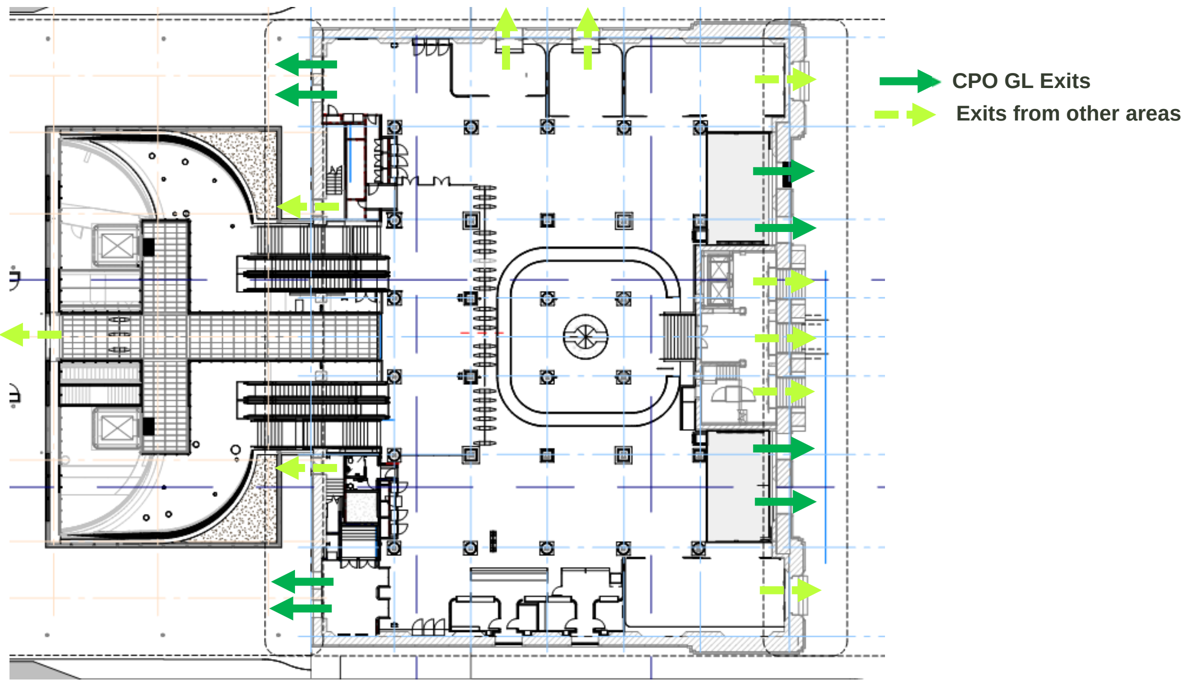


Figure 12: Egress from Britomart West at Street Level (Glasshouse and CPO) Permanent Works.

Locking devices (when the building is legally occupied) will:

- be clearly visible, located where such a device would be normally expected, designed to easily operate without a key or other security device, and allow the door to open in the normal manner;
- if of an electromagnetic type, in the event of a power failure or door malfunction, either:
  - automatically switch to the unlocked (failsafe) condition, or
  - be readily opened by an alternative method satisfying the requirements of the above.
- Panic fastenings will be fitted on doors on the means of escape from fire including exitways and final exits as required.

Britomart Transport Centre and Back-of-House Areas

Egress from the stations is via escalators and open stairs serving the platform and concourse levels (i.e., the normal access routes to and from the station) from Britomart East and Britomart West.

In addition, Permanent Works there will be a new dual purpose egress/fire intervention stair connecting platform level (B2) with Ground Level. The stair discharges into a fire lobby in the north east corner of the CPO Ground Level, which in turn discharges to outside. Level B1 Back-of-House areas fire stair (Stair 37) also connects into the egress/fire intervention stair.

The various stairs and elevators are identified in Figure 13 and Figure 14.

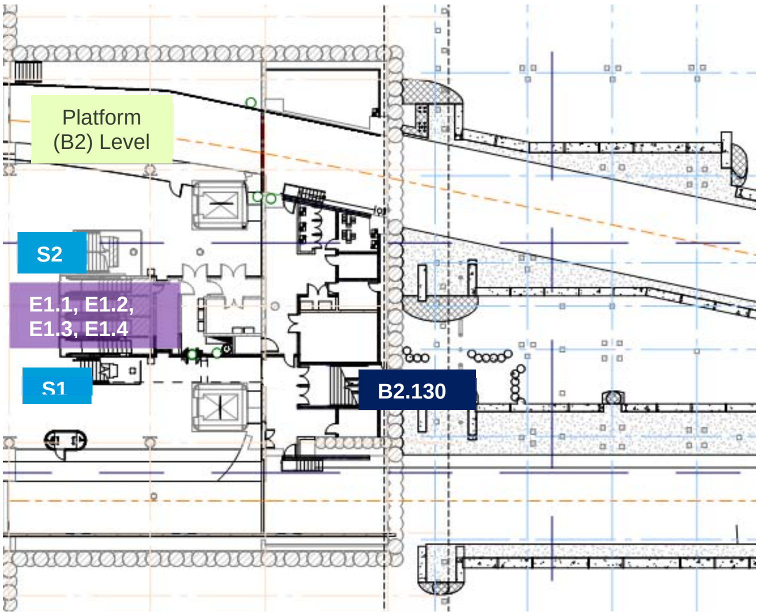


Figure 13: Stairs and Escalators Permanent Works - Platform Level (B2) to Concourse Level (B1)

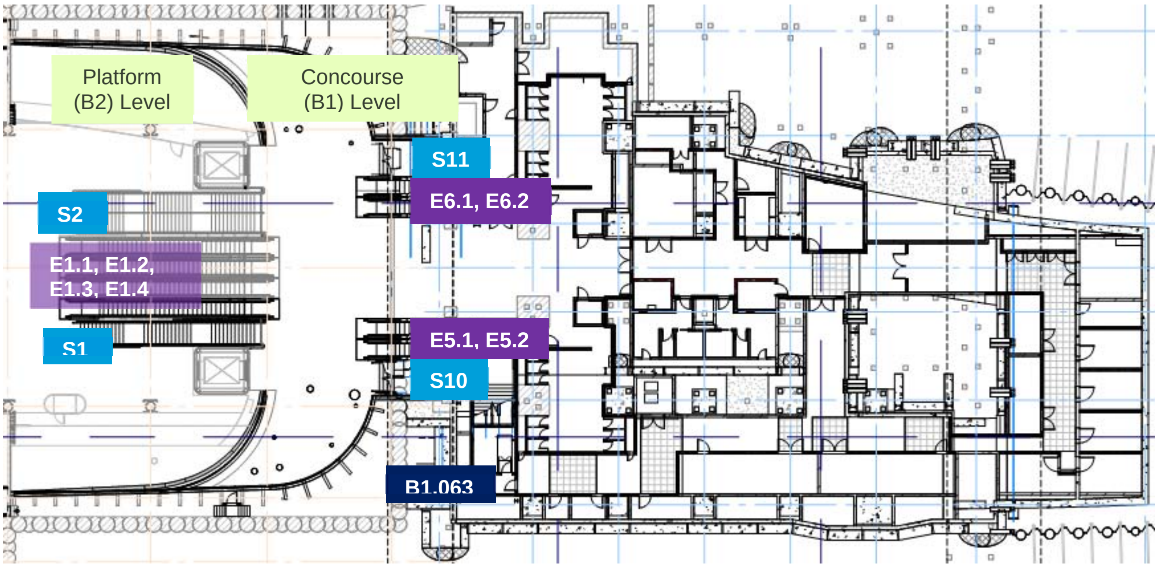


Figure 14: Stairs and Escalators Permanent Works - Concourse level (B1) to Ground Level

5.5.2 Exit Capacity

Britomart Transport Centre

At Britomart West the exit capacities from the station Permanent Works are as follows:

Table 25: Britomart West Station Exit Capacities

Level	Element	Approximate Width
Platform (B2) to Concourse (B1)	S1	1.7 m
	S2	2.9 m
	E1.1 – E1.4	1.0 m - Capacity 100 p/min*
	New Fire Intervention Stair (to Ground, no access B1)	3.2m
Concourse (B1) to Ground	S10	2.0 m
	S11	2.2 m
	E5.1, E5.2, E6.1, E6.2*	1.0 m - Capacity 100 p/min*
	Back-of-House Stair (connects to the Fire Intervention Stair)	1.0 m
Final Exits at Ground[1]	Station Entry A Station Entry B Station Entry C Station Entry D Station Entry E Station Entry F Station Entry G Station Entry H Station Entry I (Glass House)	2.3 m 2.3 m 2.3 m 2.3 m 1.5 m 1.5 m 1.5 m 1.5 m 3.6 m

* Escalators to be upgraded progressively throughout Temporary Works so that capacity will be uniformly 100 p/min

[1] For station occupants, excludes exits from other areas or through areas which may not be accessible while station is still open (i.e. through the vestibule and through the retail units). Glass house exit included for completeness however not utilised in egress calculations as it requires occupants to change direction to use as an exit.

The exit capacities at Britomart East remain unchanged and are as outlined below in Table 26.

Table 26: Britomart East Station Exit Capacities

Level	Element	Approximate Width
Platform (B2) to Concourse (B1)	Platform 1/2: S5	1.5 m wide
	Platform 1/2: E2.1	1.3 m - Capacity 100 p/min*
	Platform 3: S6	1.5 m wide
	Platform 3: E3.1	1.3 m - Capacity 100 p/min*
	Platform 4/5: S7	1.5 m wide
	Platform 4/5: E4.1	1.3 m - Capacity 100 p/min*
Concourse (B1) to Ground	S 12/13	2.8 m
	E7.1	1.5 m - Capacity 100 p/min
	E8.1	1.5 m - Capacity 100 p/min

* Escalators will be upgraded progressively throughout the Temporary Works so that capacity will be uniformly 100 p/min Permanent Works

5.5.3 Travel Distance

Temporary Entrance

The travel distances from the CPO Ground Level are within the limits provided by C/AS4.

Table 27: CPO Travel Distance

Area	Maximum allowable Dead End Open Path	Maximum allowable Total Open Path	Actual DEOP / TOP
CPO Ground Level - C/AS4	40 m	100 m	10 m (from staff only area) / 40 m

Britomart Transport Centre

The platform is approximately 160 m in length, the maximum travel distance from the end of the platform at Britomart West to the fire intervention stair is 45 m. The maximum travel distance to outside is 96 meters via the Glasshouse and 99 meters via the CPO. It has been demonstrated through ASET/RSET assessment (Appendix D) that passengers are afforded a tenable path of egress.

Britomart Transport Centre Back-of-House Areas

There are no changes to egress paths from the existing Back-of-House areas. Travel distances from the new Back-of-House areas on Level B1 and Level B2 are within the limits specified by C/AS5.

Table 28: BOH Travel Distance

Area	Maximum allowable Dead End Open Path	Maximum allowable Total Open Path	Actual DEOP / TOP
BOH - C/AS5	50 m	120 m	37 m / 50 m

Note, as per C/AS Clause 3.4.2 an open path ends either: at the start of an exitway, or a final exit, or the point where the escape route passes into an adjacent firecell on the same level (see Clause 3.7.13 which permits an open path to pass into an adjacent firecell on the same level and recommence as a new open path given a number of provisions.)

5.6 Exit Signs and Emergency Lighting

Exit signs and emergency lighting are to be provided throughout in accordance with NZBC F6 and F8, and NZS 2293.1:2005 and NZS 2293.3:2005.

Existing exit signs and emergency lighting will provide compliant coverage. Where reasonably practicable, non-complaint existing exit signs and emergency lighting should be upgraded to comply with current requirements if they currently do not.

Indicative exits sign locations are shown in Appendix A and will be located in accordance with NZBC F8.

Indicative emergency lighting requirements are noted below; however, a suitably qualified person is to design and install the emergency lighting system.

CPO

Emergency lighting will provided in the following areas with a direct illuminance of no less than specified below (as per F6/AS1 Clause1.3.1):

- Within the CPO a minimum 1 Lux

Britomart Transport Centre

Emergency lighting will provided in the following areas with a direct illuminance of no less than specified below (as per F6/AS1 Clause1.3.1):

- A minimum 1 Lux along escape routes including platform areas, stairs and escalators with lighting designed to emphasize illumination at the top and bottom steps and landings.

Britomart Back-of-House areas

Emergency lighting will provided in the following areas with a direct illuminance of no less than specified below (as per F6/AS1 Clause1.3.1):

- Within the Level B1 and Level B2 Back-of-House Corridors a minimum 1 Lux
- Within the Level B2 fire lobby a minimum 1 Lux

As per F6/AS1 Clause 1.6.1, emergency lighting must be maintained for 90 minutes.

5.7 Firefighting Provisions

5.7.1 Fire Hose Reel Systems and Fire Extinguishers

Fire extinguishers will be included in the back-of-house areas to comply with NZS 4541 Clause 209.1, locations are to be in accordance with NZS 4503-2005.

5.7.2 Fire Hydrant System

CPO

The existing fire hydrant system will be retained within the CPO building.

Britomart Transport Centre and Back-of-House areas

Existing fire hydrants providing coverage to the platforms will be maintained providing compliance with existing approved consent documentation.

The existing fire hydrant system will be extended to provide coverage to new Back-of-House areas. The fire hydrant system will comply with NZS 4510. NZFS have approved the following fire hydrant outlet locations as shown in Figure 15 and Figure 16.

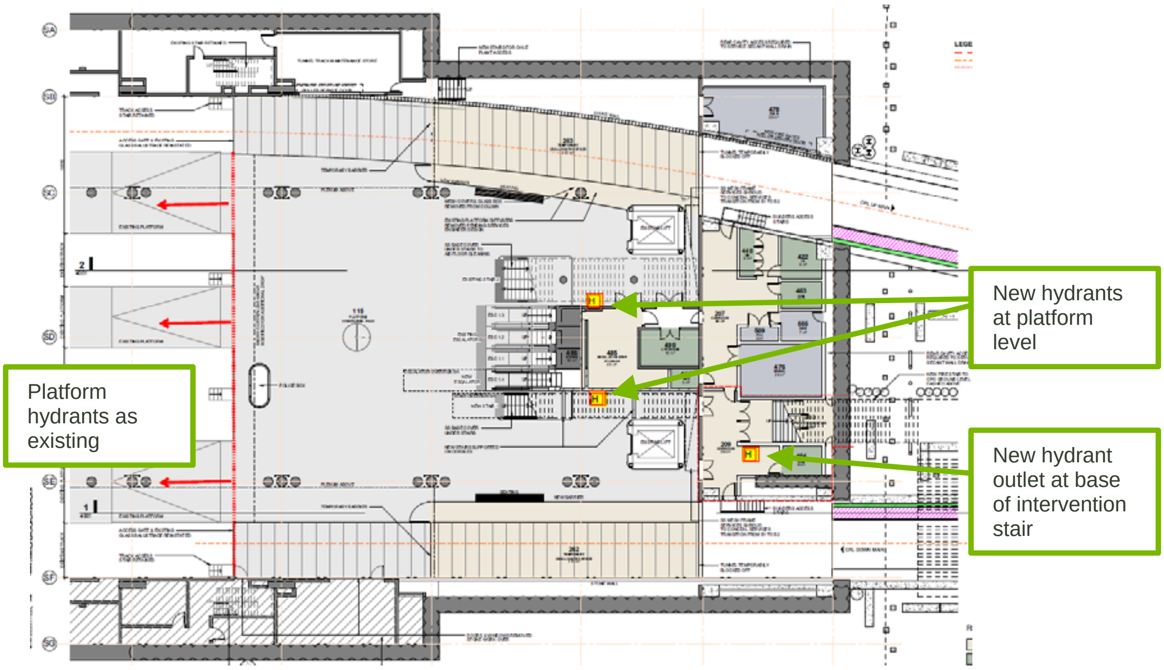


Figure 15: BOH Level B2 new fire hydrant outlets

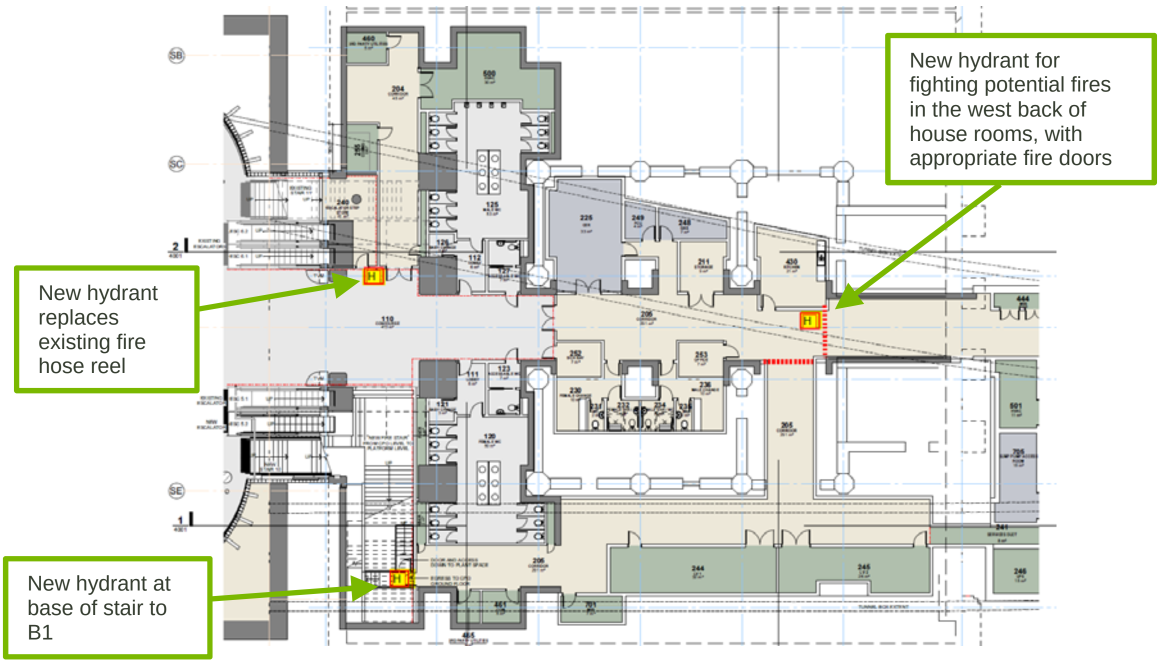


Figure 16: BOH Level B1 new fire hydrant outlets

CRL Tunnels

The fire hydrant inlet assembly for the CRL Tunnels and pipework up to the tunnel head end will be installed during the Enabling Works. It will be isolated at the connection to the tunnels, awaiting fit out of the tunnels (Post CRL Configuration Stage). The fire hydrant inlet assembly will be located within the South Vent Building in what was previously part of the Cleaners Room, as shown below in Figure 17; this configuration has been reviewed by the NZFS.

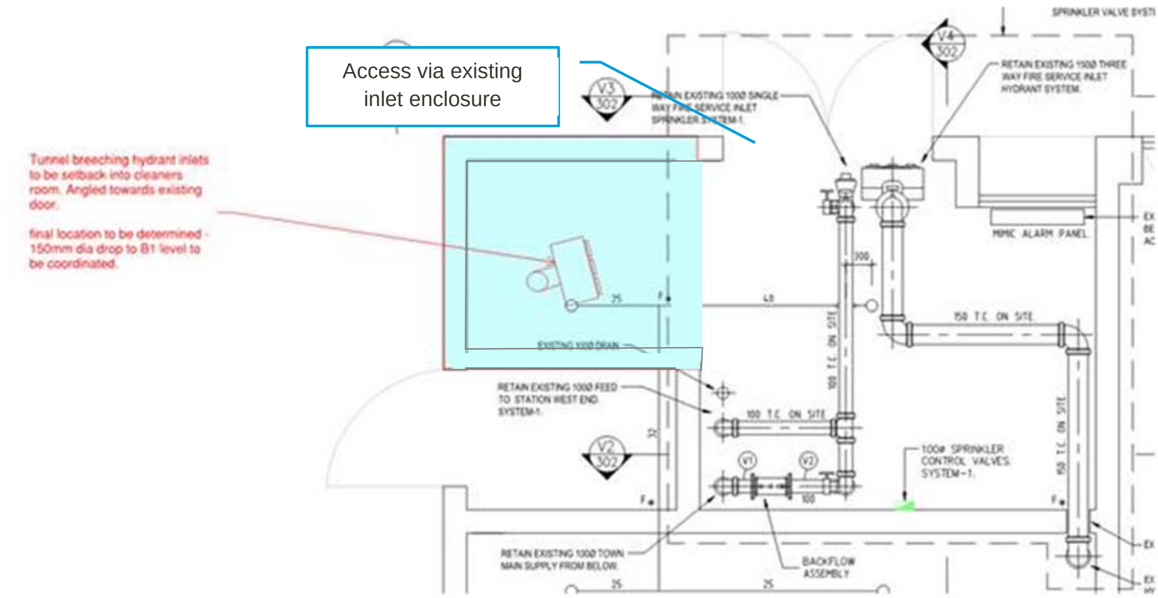


Figure 17: CRL Temporary Works Tunnels new fire hydrant outlets (within South Vent Building)

5.8 Fire Service Access

The primary Fire Service Intervention Point will remain at Britomart East (Corner of Galway Street and Britomart Place) where the fire service has protected stair access to the Main Control Room (MCR).

The secondary Fire Service Intervention Point at Britomart West will also remain at the corner of Galway and Commerce Street. The Fire Service Intervention Point at Britomart West within the South Vent Building consists of a mimic panel, fire sprinkler and hydrant inlets for both Britomart Transport Centre and the new Albert Street tunnels.

The South Vent Building also contains an entry to protected stairs to the Platform Level (B2), this will only provide access to BOH areas south of the future CRL ("Up") track.

The new Fire Intervention Stair in the North East corner of the CPO building will provide direct access to the Platform Level (B2) as well as access to Level B1 back-of house by way of the inter-connected Stair 37.

Appropriate signage/maps indicating the location of the new Intervention Stair location in North East corner of the CPO will be provided, as shown in Figure 18.

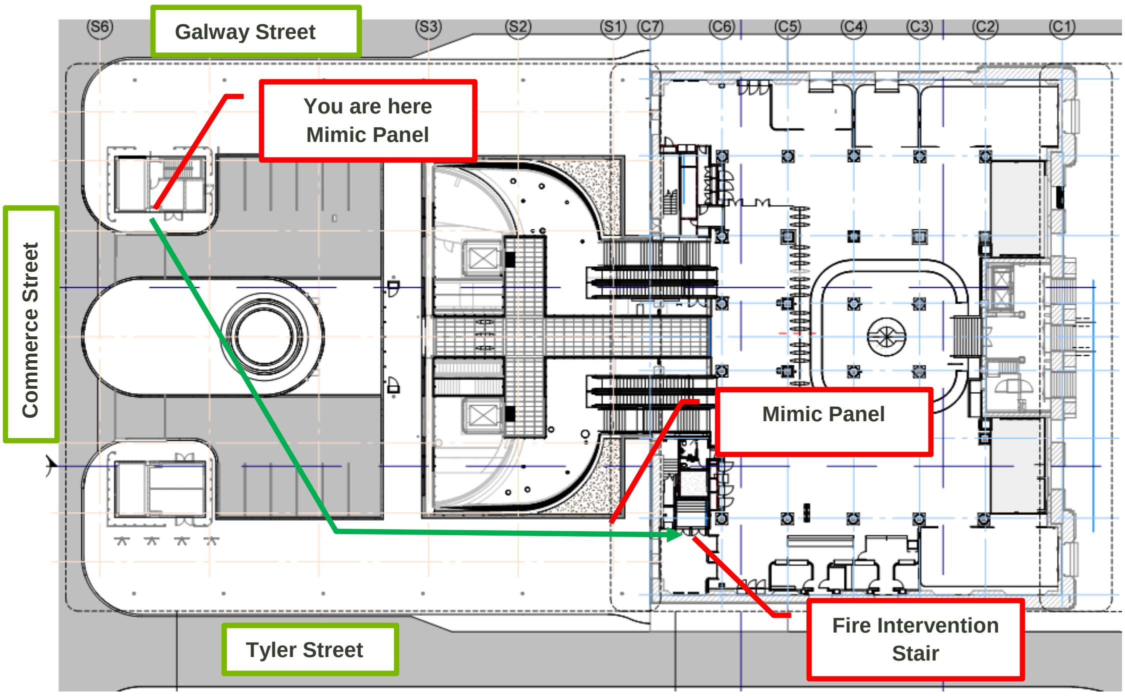


Figure 18: Fire Service access to Platform Level Permanent Works

Additional provisions to assist NZFS access will include:

- Appropriate block plans/ drawings provided adjacent to fire hydrants in BOH areas to show fire hydrant locations and paths to exits, these will also be indicated on drawings at the FAP and mimic panels.
- Signage will be provided to indicate access to the Temporary Works Tunnels and specific emergency response requirements.

5.9 Testing and Commissioning

Following the completion of the Temporary Works (e.g., Permanent Works conditions), the fire safety systems including Britomart ventilation system and SCADA controls will undergo concurrent 'end-to-end' test of the system interfaces to confirm that they operate in accordance with the approved design.

The Britomart ventilation system and SCADA controls will require re-commissioning following changes to the system to ensure that appropriate flow rates are achieved by fans, and that the operational modes are activated by the appropriate fire alarm signals.

Re-commissioning and testing will focus in particular on:

- The SCADA and Occupant Warning Response to new fire alarm signals from the CPO (Britomart West B1 BOH & Public Toilets, Ground Level and Upper Floors)
- The revised SCADA (ventilation) response for a fire alarm at platform level
- Air flow rates delivered by fan sets operated for station fire incidents
- Air flow rates at key locations in the station and tunnels for the various fire modes (e.g., longitudinal tunnel flow rates, flow rates in vertical transport routes)

Note: Following any changes to the Tunnel Ventilation Strategy for Britomart Tunnels, additional testing and commissioning may be necessary. This is beyond the scope of this report.

5.10 Management in Use & Operational Requirements

5.10.1 Routine Maintenance

CCTV, PIDS and PA systems will be identified as specified systems and included in the site's compliance schedule to ensure they are routinely maintained and inspected as they are an integral part of the fire safety strategy.

The compliance schedule will be amended to reflect Permanent Works conditions.

5.10.2 Management in Use

As part of the management in use procedure:

- Evaluation by qualified engineers of proposed retail and furniture and installations for conformance to design limitations.
  - Advertising materials provided within a non-combustible housing
  - Permanently fixed furniture within the station shall be non-combustible
  - Significant increases in fuel load (temporary or permanent), e.g. art installations involving combustible materials, pop up stores, etc. are not permitted unless specifically assessed on a case-by-case basis.
- AT will monitor occupant loads within the station, limiting the platform population to no more than 2,600. Where there are unexpected surges in occupant loads (e.g., special events, system disruptions) staff will direct occupants to appropriate exits to assist in clearing the platforms and prevent additional occupants entering the platform area via shutting of ticketing gates.

5.10.3 Emergency Response

Emergency response will be modified to account for changes in evacuation strategy due to Permanent Works conditions. There are no further significant changes proposed to the existing emergency strategy, which are documented in the Emergency Response Manual (ERM).

A summary of the emergency response procedure is as follows:

- Manual detection via a Help Point or manual call point or over staff radio is generally expected to occur prior to automatic detection via detector or sprinkler.
- The Main Control Room or Station Controller will manually activate the appropriate fire systems.
- Activation of the sprinkler system will automatically initiate the fire system response associated with the fire sprinkler zone.
- Automatic detection will notify the Main Control Room/ Station Controller who will utilise CCTV and staff in the vicinity of the alarm to verify the alarm. The system is provided with a 60-second delay after which it will automatically initiate the appropriate fire system response.
- The Station Controller has the ability to manually override all fire systems to force activation or to stop activation.
- In a fire event the Station Controller has set procedures for the management of fire operations including activation of appropriate fire systems and the notification of emergency services.
  - Signals will prevent trains from entering the tunnel and platform areas. The Station Controller and CTC have control to instruct trains at platforms to depart the Station if appropriate.
  - Occupant evacuation appropriate to the fire location is directed via PA announcements and PIDS messaging.
  - SCADA response appropriate to the fire location will control exhaust and supply fans.

- On automatic activation, smoke exhaust and occupant warning is activated according to the predetermined response to the specific fire event.
- On manual activation, smoke exhaust and occupant warning is activated according to the predetermined response to the specific fire event or as deemed appropriate by the Station Controller.
- Platform staff are trained to carry out fire emergency procedures which include provisions for assisting occupants requiring help, manually controlling escalators, directing occupants to exits, and keeping order.

5.10.3.1 Emergency Response Matrix

The following Emergency Response Matrix is for Britomart West fire events and is high level and provided for illustrative purposes. It has utilised and refers to the fire scenarios/modes in the SCADA system for clarity.

Fire Scenario	Fire at Station Platforms	Fire in West End B2 BOH	Fire in West End B1 BOH[1]	Fire in CPO Ground	Fire in CPO Upper Levels	Fire in Glasshouse
Activating device						
Manual	Y	Y	Y	Y	Y	Y
Detection	Y	Y	Y	Y	-	-
Sprinkler	-	Y	Y	Y	Y	-
Platform Evacuation						
All out	Y	Y	Y	-	Y	-
Direct towards Britomart East	-	-	-	Y	-	Y
Direct towards Britomart West	-	-	-	-	-	-
Other Systems						
SCADA Mode	1	7	8	9	10	9
Air Handling Systems	Off	Off	Off *	Off *	Off	Off
Escalators Britomart East	Up	Up	Up	Up	Up	Up
Escalators Britomart West	Up	Up	Up	Down	Up	Down
Smoke Curtain Deploys	Y	-	-	-	-	-

1. Name change from pre Temporary Works

* except: Minor systems (openings not exceeding 0.1 m²), or Air handling systems servicing UPS rooms to shut down on local alarm only

5.10.3.2 Staff Response/ Occupant Warning

The existing consent documentation and FER outlines the occupant warning requirements which have been reproduced in part:

> *"Staff at the MCR are trained to manage the evacuation of the station. A mimic fire indicator panel (FIP) is located within the MCR for BTC staff use.*

The station PA system is used to broadcast evacuation messages to passengers. The PA system can broadcast live or pre-recorded evacuation messages. The PA system has an uninterruptible power supply (UPS) to ensure its continued operations during a power outage.

To provide warning to people in Back-of-House areas where high ambient noise levels are present, visual signalling in conjunction with audible sounders is used.

The passenger information display system (PIDS) that is installed throughout the station notifies occupants to evacuate by the nearest exit. The PIDS system is able to display messages alerting occupants to an emergency and indicating that evacuation should occur. In an emergency, the SCADA system takes control of the PIDS away from the train information function, to display evacuation messaging as described in the O&M manual.

Various PIDS messages can be displayed as a flashing message. The choice of message depends on nominated direction of egress."

The following alterations are required to accommodate changes in evacuation strategy from Temporary Works to Permanent Works. PID messages will be altered to:

- Remove references to Temporary Entrance,

The Emergency Response Manual (ERM) with staff response will also be altered to:

- Direct occupants to the Fire Intervention Stair in the event of an emergency event.

5.10.3.3 Persons Requiring Assistance

The strategy for persons requiring assistance remains the same, as per the existing consent documentation and FER.

"Occupants who are deaf can be visually warned via the PIDS. Occupants who are blind may need to be assisted by BTC staff or other occupants.

The Emergency Response Manual (ERM) for the station requires designated staff members to aid persons requiring assistance, including children, disabled, ambulant disabled and elderly persons, by directing them up escalators and stairways.

Escalators can be used as part of a managed system for occupants requiring assistance. This practice has been adopted in many countries as people requiring assistance can be helped on and off escalators by staff members. Wheelchair-bound occupants can be assisted onto the escalators and, provided they are appropriately supported, can use them to escape. The BTC escalators are designed with a longer horizontal entry and run-off length of three steps, in lieu of the normal two. This improves escalator safety during normal and emergency operations."

Permanent Works, persons requiring assistance are also provided with a safe place within the fire lobby on Level B2.

6 Conclusion

As required by the New Zealand Building Act, the fire safety design for the Britomart Transport Centre during the Temporary Works and Permanent Works stages will achieve compliance with the New Zealand Building Code C Clauses, amended by the clarifications, modifications and waivers, which have been agreed in principle by the Auckland Council and MoBIE, and where applicable the provisions outlined in Section 112 of the Building Act.

In order to achieve compliance the Britomart Transport Centre is required to meet the fire and life safety measures outline in this report:

- Temporary Works - The fire and life safety measure are specified in Section 4
- Permanent Works - The fire and life safety measure are specified in Section 5

The assessments carried out to substantiate areas requiring specific fire engineering are included in the Appendices.

- Appendix A includes indicative drawings showing locations and ratings of fire separations, hydrant locations, areas provided with sprinkler protection, areas provided with fire (smoke) detection, and exit sign locations.
- Appendix B provides an overview of the methodology utilized throughout for assessing and comparing Available Safe Egress Time (ASET) to Required Safe Egress Time (RSET). This general methodology is used throughout subsequent appendices in assessing specific areas of Britomart Transport Centre.
- Appendix C and D assess life safety conditions during the Temporary Works for the Temporary Entrance and Britomart Transport Centre (station platform), respectively.
- Appendix E and F assess life safety conditions during the Permanent Works for Britomart Transport Centre (station platform) and the (reinstated) CPO, respectively.
- Appendix G, H, I, and J provide additional detailed results from the computational fluid dynamics (CFD) modeling undertaken as part of the life safety assessments.
- Appendix K provides an exemplar egress calculation to detail the methodology utilized in estimating required safe egress times.

The contents of the appendices are intended to be reviewed in conjunction with this report as substantiation of the specific fire engineering design utilized in justification of the Britomart Transport Centre station platform design.

7 References

7.1 Studies & Reports for Britomart Transport Centre

[1] CRL-BTM-FIR-000-RPT-0005 Temporary Works Fire Engineering Brief – Britomart Transport Centre, Revision 3, 19 June 2015, Arup

[2] Auckland Transport, Auckland City Britomart Transport Centre, Fire Engineering Report, Revision 8, 28 February 2016, Stacey Agnew Pty Ltd.

[3] Auckland Transport, Auckland City Britomart Transport Centre, Fire Engineering Brief, Revision 2.0, 20 February 2014, Stacey Agnew Pty Ltd.

[4] Britomart Transport Centre, CPO Building Auckland, Section 112 Review, Revision C, 7 March 2014, Cross Fire

[5] Infleet Technology NZ Ltd, Britomart Transport Centre Life Safety Review 3586-R01, Revision 1.0, 26 August 2011, Stacey Agnew Pty Ltd

[6] Support Phase – Britomart Transport Centre Review 228072-AC-RPT-085

[7] Auckland City, Queen Street Station Fire Safety Strategy, Issue 2, September 2001, Arup Fire

7.2 Studies & Reports for CRL

[8] CRL-SYW-FIR-000-RPT-0002 Electric Rolling Stock Fire Sizes

[9] CRL-SYW-FIR-000-MAN-0007 Draft Design Manual Volume 1 Part 7: Fire Engineering Brief

[10] CRL-PAT-FIR-000-RPT-0010 Temporary Works Addendum Fire Engineering Brief – C1, Precinct and C2 Tunnels

[11] CRL-BTM-TPP-000-RPT-0008: Contract 1 Accommodation Works Volume 5: Passenger Modelling (Detailed Design)

[12] CRL-BTM-TPP-000-RPT-0009: Contract 1 Permanent Works Volume 5: Passenger Modelling (Detailed Design)

7.3 New Zealand Legislation, Regulations, Codes and Standards

[13] New Zealand Building Act, 2005.

[14] New Zealand Building Regulations, 1992.

[15] Extract from the NZBC, Clauses C1 – C6 Protection from Fire, Clause A3 Building Importance Levels, 10 April 2012, Department of Building and Housing

[16] Acceptable Solutions: C/AS4 Amendment 3, C/AS5 Amendment 3, D1/AS1 second edition amendment 5, F6 third edition amendment 3, F7 fourth edition, F8 signs second edition amendment 3, Ministry of Business, Innovation & Employment

[17] Verification Method, C/VM2 verification method: Framework for fire safety design, amendment 4, Ministry of Business, Innovation & Employment

[18] NZS 4512 Fire detection and alarm systems in buildings, 2010

[19] NZS 4541 Automatic fire sprinkler systems, 2013

[20] NZS 4510 Fire hydrant systems for buildings, 2008

7.4 Australian Codes and Standards

[21] AS 1530 Methods for fire tests on building materials, components and structures; Part 1: Combustibility test for materials,1994

[22] AS 1530 Methods for fire tests on building materials, components and structures; Part 2: Test for flammability of materials,1993

[23] AS 1530 Methods for fire tests on building materials, components and structures; Part 4: Fire-resistance tests of elements of building construction, 2005

[24] AS/NZS 1668.1 The use of ventilation and air conditioning in buildings - Fire and smoke control in multi-compartment buildings, 1998

[25] AS 4825 Tunnel Fire Safety, 2011

7.5 International Codes and Standards

[26] International Fire Engineering Guidelines; Australian Building Codes Board; 2005.

[27] BRE 368:1999, Design methodologies for smoke and heat exhaust ventilation, BRE, 1999

[28] NFPA 101: Life Safety Code: 2012.

[29] NFPA 130; Standard for Fixed Guideway Transit and Passenger Rail Systems; 2014.

[30] PD 7974: Part 6, The application of fire safety engineering principles to fire safety design of buildings – human factors, life safety strategies – occupant evacuation, behaviour and condition, 2004

7.6 General references

[31] DiNenno P.J. (Editor-in-Chief), The SFPE Handbook of Fire Protection Engineering, 4th Edition, National Fire Protection Association and Society of Fire Protection Engineers, 2008

[32] J.P, 1986. Heat Transfer, Sixth. ed. McGraw-Hill

[33] ASHRAE Fundamentals Handbook, 1997

[34] Buchanan, A, Structural Design for Fire Safety

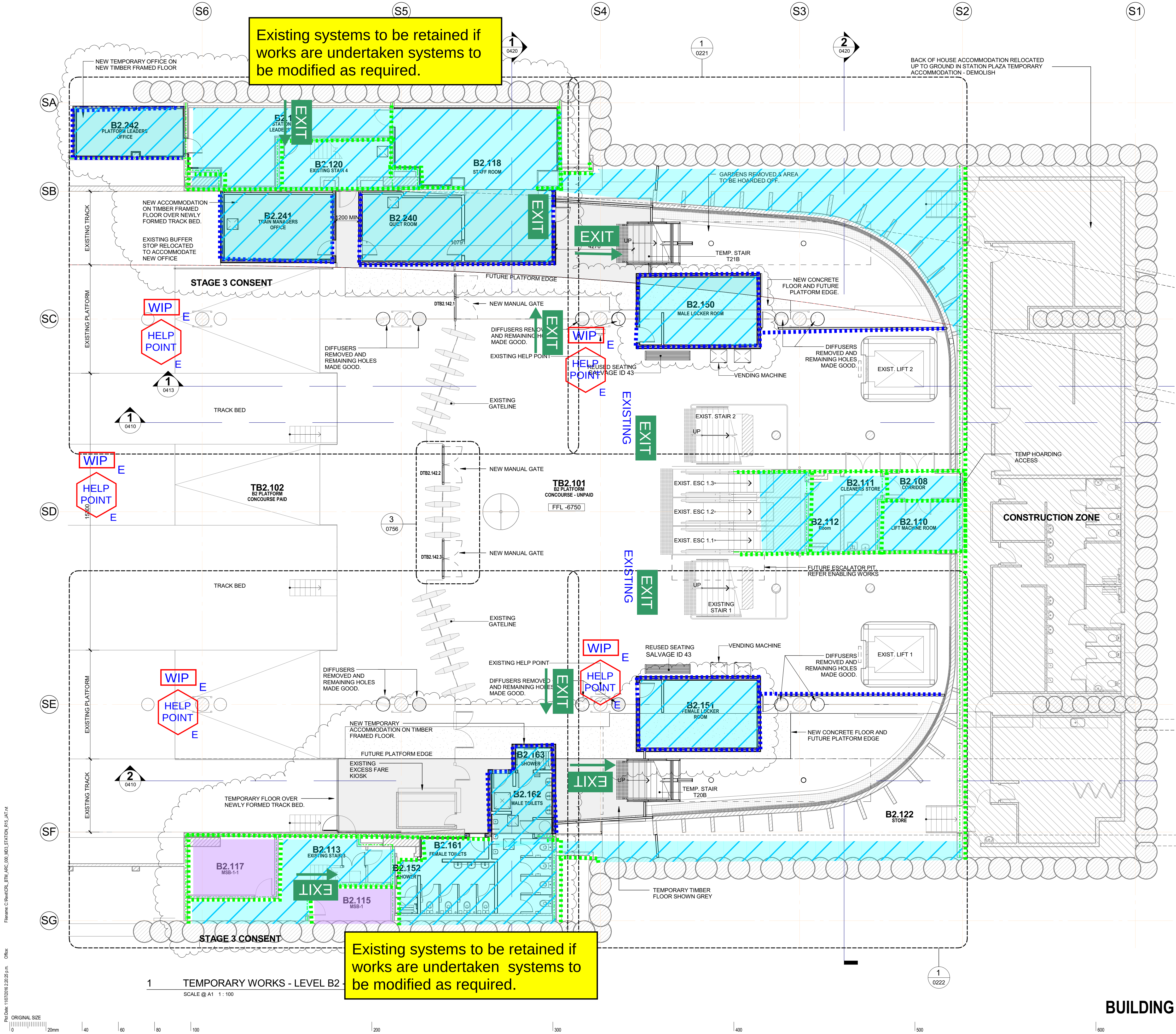
[35] Bejan, A, Heat Transfer

[36] New Zealand Fire Service Commission, Annual Report – for the ending 30 June 2015, 2015

[37] Spearpoint, M (ed.), Fire Engineering Design Guide, 3rd Edition, NZCAE

Appendices

Appendix A – Indicative Drawings



Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
- Area protected by gas suppression system
- EXIT — Indicative Exit Sign Locations
- WIP — Warden Intercom Point
- MCP — Manual Call Point
- HELP POINT — Public Help Point

aurecon GRIMSHAW MOTT MACDONALD Jasmax ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	10/12/15	DETAIL DESIGN 100%	Liam Wythes
E	11/03/16	AT REVIEW	Liam Wythes
F	18/03/16	BUILDING CONSENT	Liam Wythes
G	07/04/16	STAFF TOILET LAYOUT CHANGE	
H	03/06/16	STAGE 3 (B2 ACCOM) FOR AT REVIEW	Liam Wythes
J	11/07/16	STAGE 3 BUILDING CONSENT	Liam Wythes

SCALE: As indicated — SIZE: A1 — DETAILED DESIGN NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes — DATE

PROJECT: AUCKLAND CITY RAIL LINK EC1 BRITOMART & LOWER QUEEN ST.

TITLE: TEMPORARY WORKS - FLOOR PLAN - LEVEL B2

BUILDING CONSENT

DOCUMENT						
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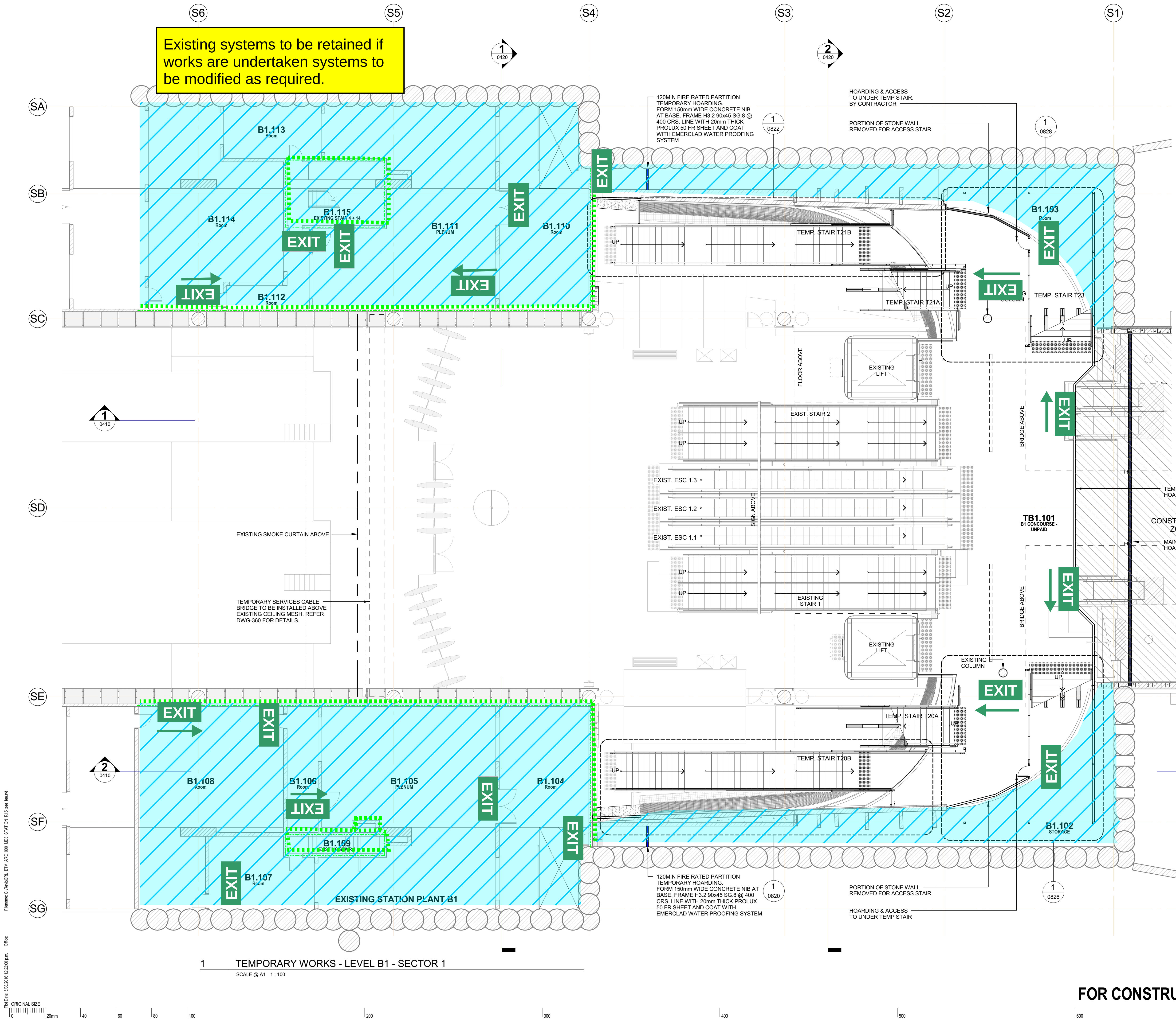

FOR CONSTRUCTION

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
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- WIP — Warden Intercom Point
- MCP — Manual Call Point
- HELP POINT — Public Help Point

FOR ALL STRUCTURAL STEELWORK REFER TO STRUCTURAL ENGINEER'S DRAWINGS FOR VERIFICATION OF MEMBER SIZES

aurecon GRIMSHAW

MOTT MACDONALD Jasmax ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
A	31/08/15	FOR COORDINATION	
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	10/12/15	DETAIL DESIGN 100%	Liam Wythes
E	11/03/16	AT REVIEW	Liam Wythes
F	18/03/16	BUILDING CONSENT	Liam Wythes
G	11/07/16	STAGE 3 BUILDING CONSENT	Liam Wythes
1	04/08/16	ISSUED FOR CONSTRUCTION	Liam Wythes

SCALE: As indicated | SIZE: A1

FOR CONSTRUCTION

DRAWN: Jasmax

APPROVED: Liam Wythes | DATE

DESIGNED: Chris Jack / Martin Walton

CHECKED: Martin Walton

PROJECT: AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE: TEMPORARY WORKS - FLOOR PLAN - LEVEL B1

DOCUMENT

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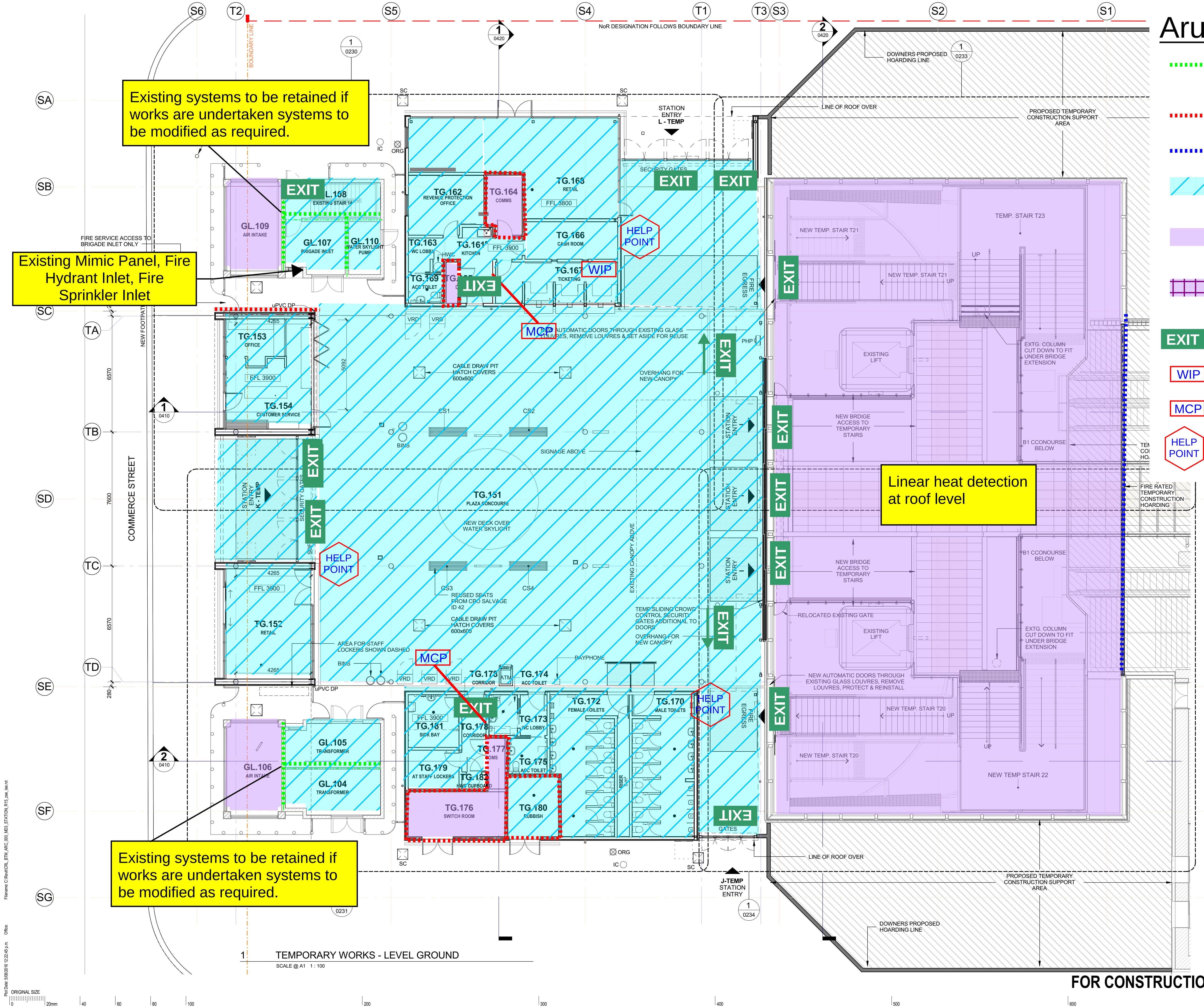

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
- Area protected by gas suppression system
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- WIP — Warden Intercom Point
- MCP — Manual Call Point
- HELP POINT — Public Help Point

aurecon GRIMSHAW
MOTT MACDONALD
Jasmax
ARUP

CLIENT

AT

REV	DATE	REVISION DETAILS	APPROVAL
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	Liam Wythes
D	10/12/15	DETAIL DESIGN 100%	Liam Wythes
E	11/03/16	AT REVIEW	Liam Wythes
F	18/03/16	BUILDING CONSENT	Liam Wythes
G	06/05/16	STAGE 2 FOR AT REVIEW	Liam Wythes
H	03/06/16	STAGE 2 BUILDING CONSENT	Liam Wythes
1	04/08/16	ISSUED FOR CONSTRUCTION	Liam Wythes

SCALE: As indicated — SIZE: A1 — FOR CONSTRUCTION

DRAWN: Jasmax

APPROVED — DATE

DESIGNED: Chris Jack / Martin Walton

CHECKED: Martin Walton — Liam Wythes

PROJECT: AUCKLAND CITY RAIL LINK EC1 BRITOMART & LOWER QUEEN ST.

TITLE: TEMPORARY WORKS - FLOOR PLAN - LEVEL GROUND

DOCUMENT

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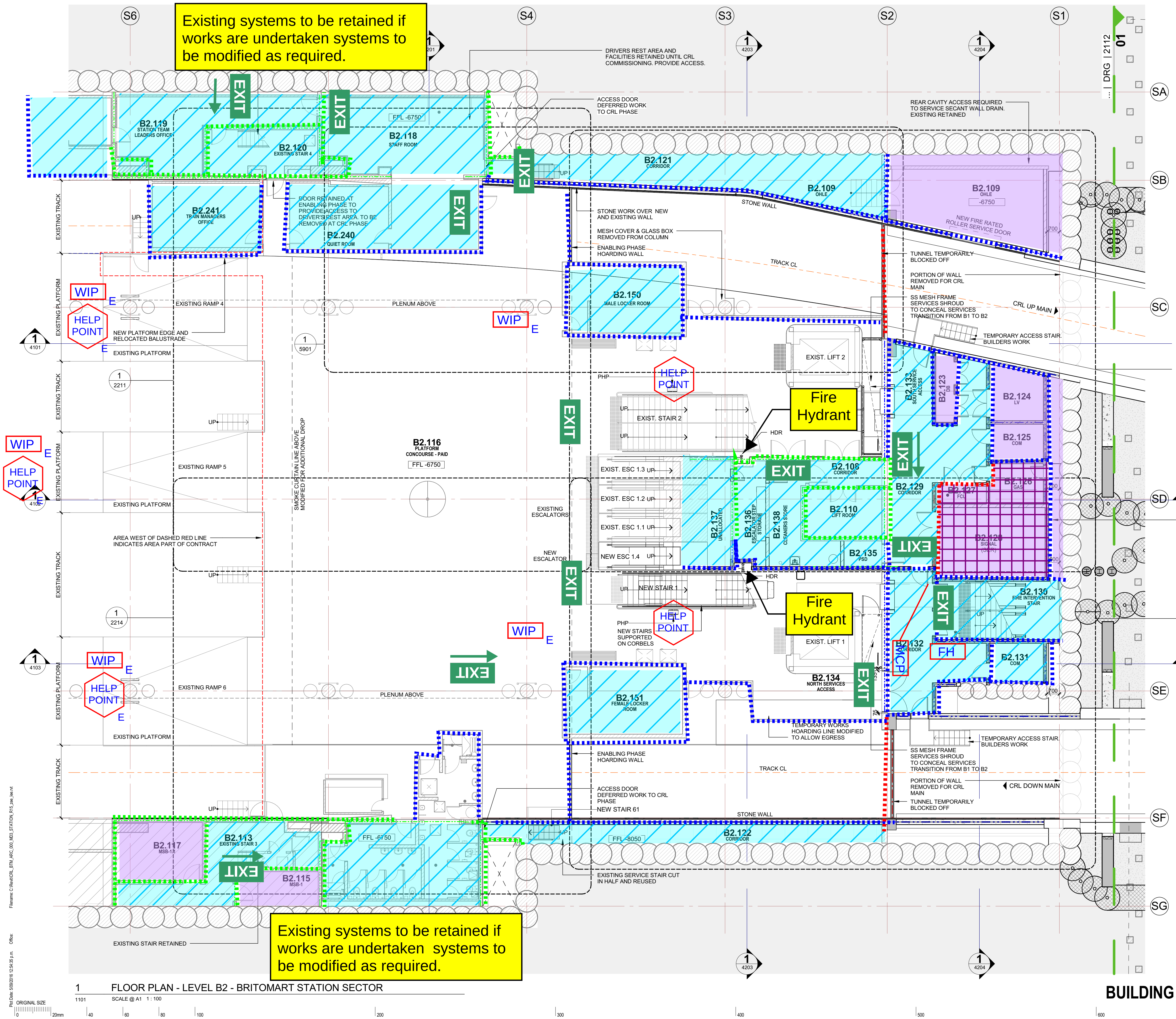
FOR CONSTRUCTION



Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
- Area protected by gas suppression system
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- MCP — Manual Call Point
- HELP POINT — Public Help Point

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MOTT MACDONALD
Jasmax
ARUP

CLIENT

AT

REV	DATE	REVISION DETAILS	APPROVAL
A	31/08/15	FOR COORDINATION	
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE: As indicated | SIZE: A1

DETAILED DESIGN
NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes — DATE

PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
BRITOMART STATION - PERMANENT WORKS - FLOOR PLAN - LEVEL B2

BUILDING CONSENT

DOCUMENT

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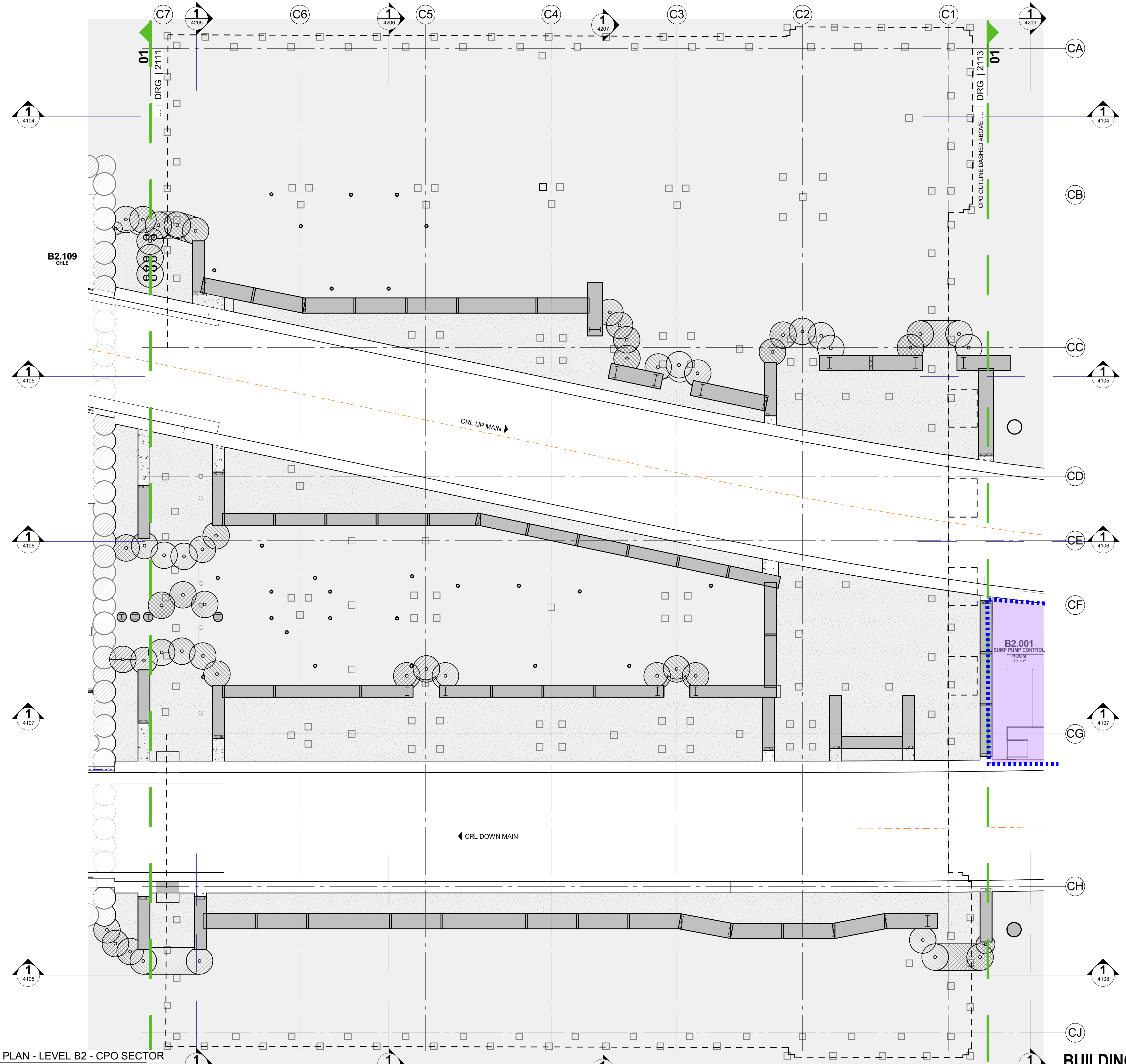

1 FLOOR PLAN - LEVEL B2 - CPO SECTOR

SCALE @ A1 1 : 100

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
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- HELP POINT — Public Help Point

aurecon GRIMSHAW
MOTT MACDONALD
Jasmax
ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
A	31/08/15	FOR COORDINATION	
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE	SIZE
As indicated	A1

DETAILED DESIGN
NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes DATE

PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
CHIEF POST OFFICE (C.P.O.)
- PERMANENT WORKS -
FLOOR PLAN - LEVEL B2

BUILDING CONSENT

DOCUMENT

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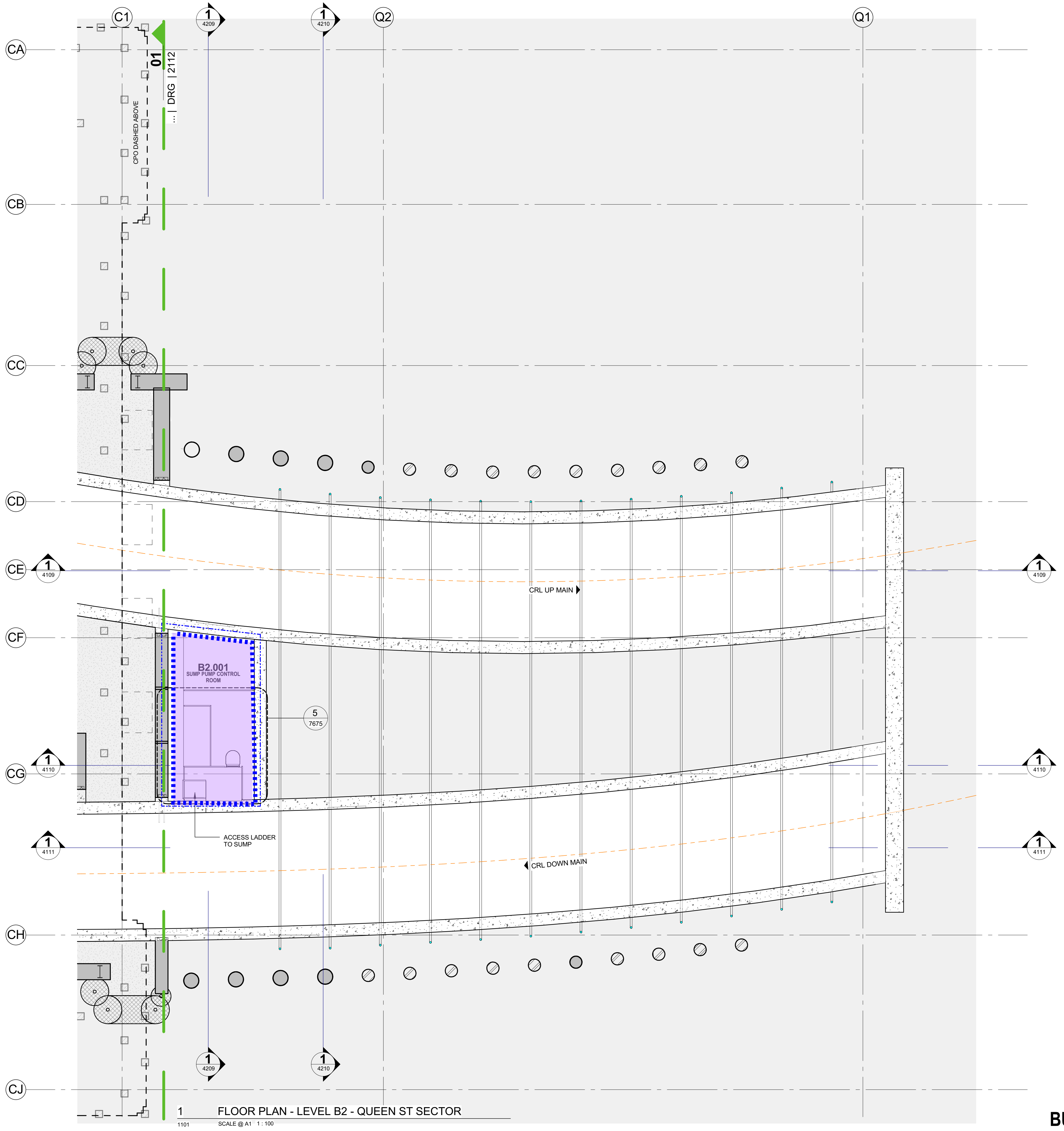

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1101 SCALE @ A1 1 : 100

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
- Area protected by gas suppression system
- EXIT Indicative Exit Sign Locations
- WIP Warden Intercom Point
- MCP Manual Call Point
- HELP POINT Public Help Point

ENGINEER'S DRAWINGS FOR VERIFICATION OF MEMBER SIZES

aurecon GRIMSHAW MOTT MACDONALD Jasmax ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
A	31/08/15	FOR COORDINATION	
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE	SIZE
As indicated	A1

DETAILED DESIGN
NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes
DATE

PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
QUEEN STREET - PERMANENT WORKS - FLOOR PLAN - LEVEL B2

BUILDING CONSENT

DOCUMENT

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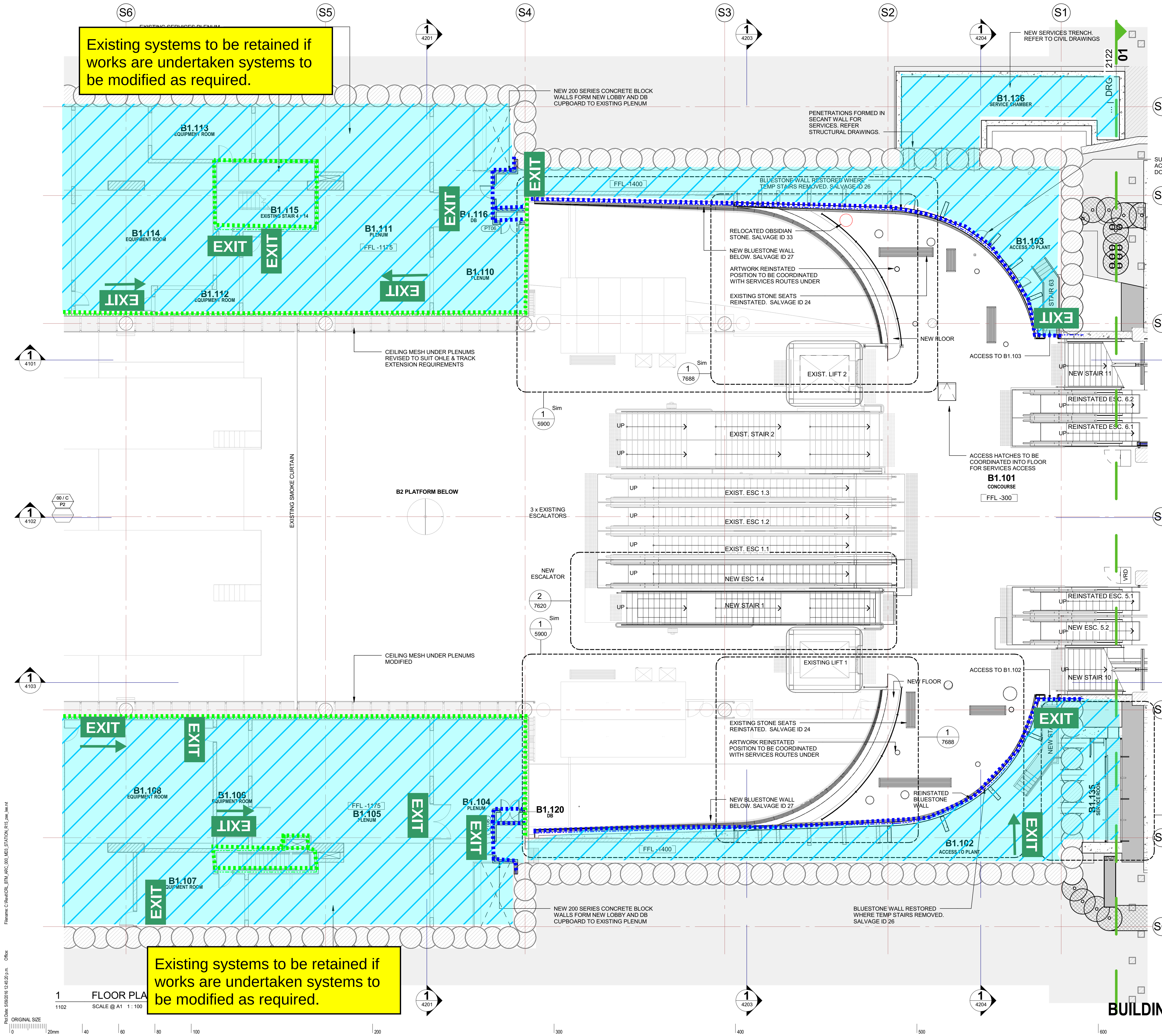

Arup Markup Legend

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- Area sprinkler protected in accordance with NZS4541
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ENGINEER'S DRAWINGS FOR VERIFICATION OF MEMBER SIZES

aurecon GRIMSHAW MOTT MACDONALD Jasmax ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
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B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE	SIZE
As indicated	A1

DETAILED DESIGN
NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes
DATE

PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
BRITOMART STATION - PERMANENT WORKS - FLOOR PLAN - LEVEL B1

BUILDING CONSENT

DOCUMENT

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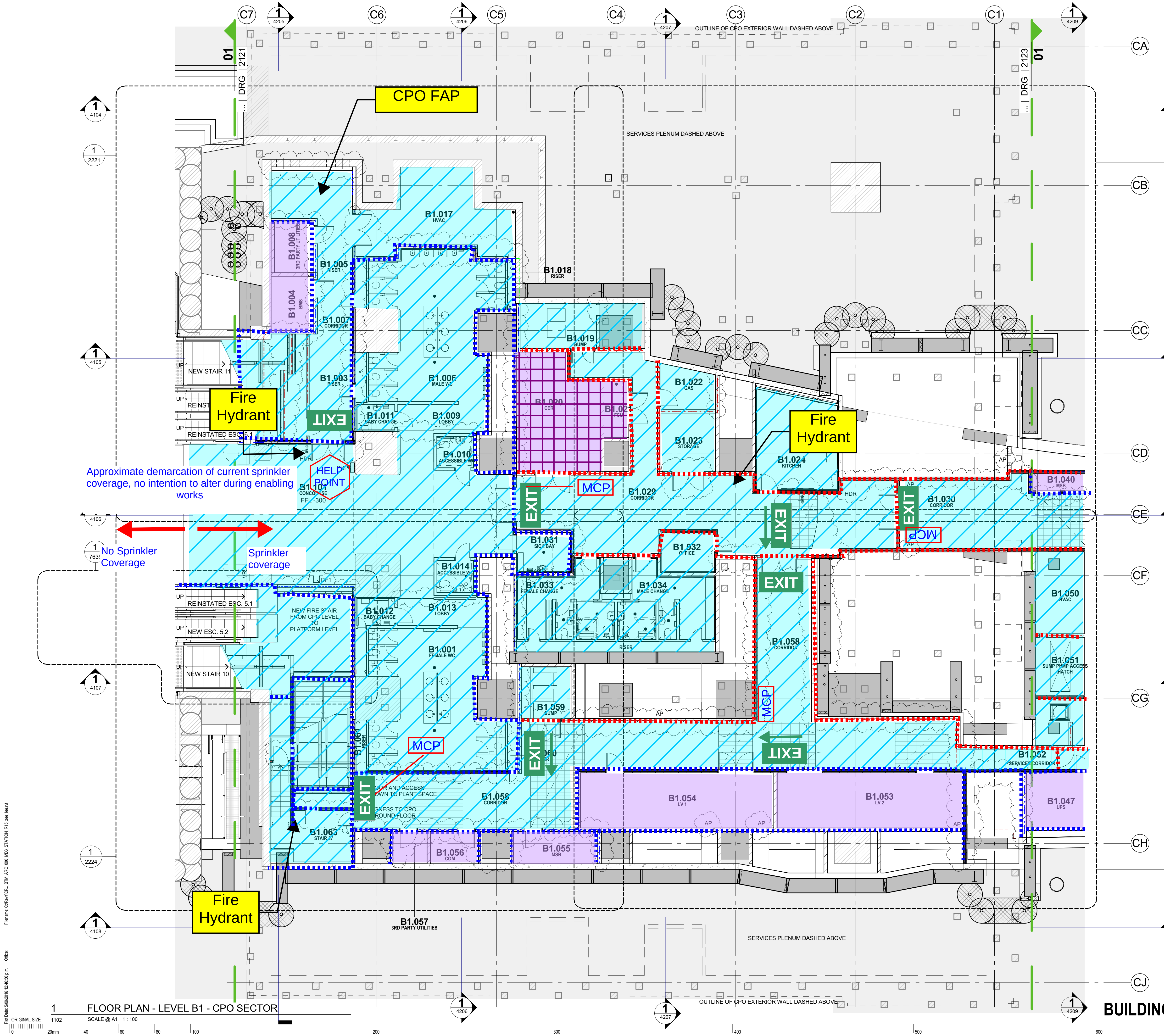

1 FLOOR PLAN - LEVEL B1 - CPO SECTOR
SCALE @ A1 1 : 100

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
- Area protected by gas suppression system
- EXIT — Indicative Exit Sign Locations
- WIP — Warden Intercom Point
- MCP — Manual Call Point
- HELP POINT — Public Help Point

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MOTT MACDONALD
Jasmax
ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
A	31/08/15	FOR COORDINATION	
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE: As indicated
SIZE: A1
DETAILED DESIGN NOT FOR CONSTRUCTION
DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes
DATE

PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
CHIEF POST OFFICE (C.P.O.)
- PERMANENT WORKS -
FLOOR PLAN - LEVEL B1

DOCUMENT

PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
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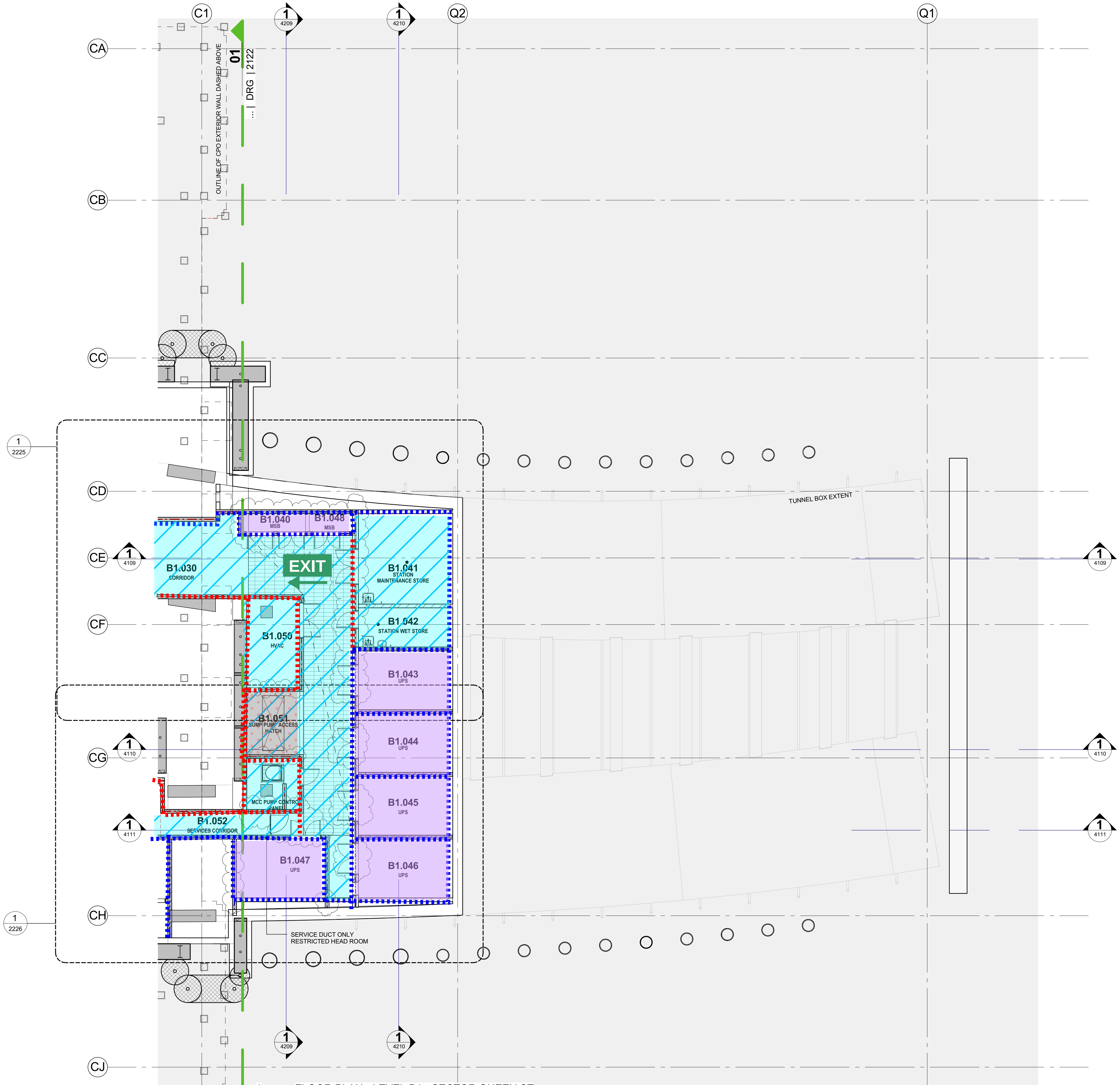
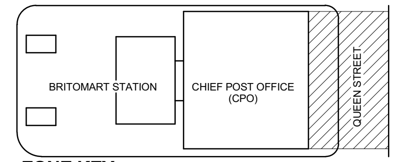
BUILDING CONSENT



1 FLOOR PLAN - LEVEL B1 - SECTOR QUEEN ST

1102 SCALE @ A1 1 : 100



ZONE KEY

LEGEND

- NoR DESIGNATION
- TRACK CENTRELINE
- FIRE RATING -/60/60
- FIRE RATING -/60/60 EXISTING
- FIRE RATING -/120/120
- FIRE RATING -/120/120 EXISTING
- CONSTRUCTION ZONE
- EXISTING CONSTRUCTION

1. PT24 : DENOTES WALL TYPES KEY, REFER TO 7500 SERIES DRAWINGS
2. SUBSTITUTION FOR OR AMENDMENT OF SPECIFIED DETAILS OR MATERIALS SHALL NOT BE CARRIED OUT WITHOUT PRIOR APPROVAL OF THE ARCHITECT
3. ALL INTERNAL PARTITIONS ARE DIMENSIONED TO THE FACE OF FRAMING UNLESS NOTED OTHERWISE. SET OUT ALL WALLS FIRST PRIOR TO FRAMING.
4. FOR SETOUT DIMENSION OF ALL HANDBASINS, SINKS AND CLEANER'S SINKS, REFER TO 5500 SERIES DRAWINGS
5. DOOR NIBS ON HINGE SIDE 100MM UNLESS DETAILED OR NOTED OTHERWISE
6. FOR STRUCTURAL SETOUT PLANS, REFER TO 2400 SERIES DRAWINGS
7. FOR REFLECTED CEILING PLANS, REFER TO 3000 SERIES DRAWINGS
8. FOR STAIRS DETAILS, REFER TO 7620 SERIES DRAWINGS
9. FOR TOILET LAYOUT AND DETAILS, REFER TO 5700 SERIES DRAWINGS
10. FOR FINISHES PLANS, REFER TO 7900 SERIES DRAWINGS
11. SELECTION AND DISTRIBUTION OF VRD TO BE CONFIRMED BY CLIENT PRIOR TO FRAMING OF WALL
12. FOR REINSTATED SALVAGE ITEMS REFER SCHEDULE CRL-BTM-ARC-000-SCH-0007

CONTRACTOR MUST VERIFY ALL DIMENSIONS ON SITE BEFORE COMMENCING ANY WORK.
NO BUILDING WORK SHALL PROCEED UNTIL BUILDING CONSENT HAS BEEN GRANTED FOR THE WORK DESCRIBED.
DO NOT SCALE OFF THIS DRAWING
FOR ALL STRUCTURAL STEELWORK REFER TO STRUCTURAL ENGINEER'S DRAWINGS FOR VERIFICATION OF MEMBER SIZES

aurecon GRIMSHAW
MOTT MACDONALD Jasmax ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
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C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE	SIZE
As indicated	A1

DETAILED DESIGN
NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes
DATE

PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
QUEEN STREET - PERMANENT WORKS - FLOOR PLAN - LEVEL B1

BUILDING CONSENT

DOCUMENT

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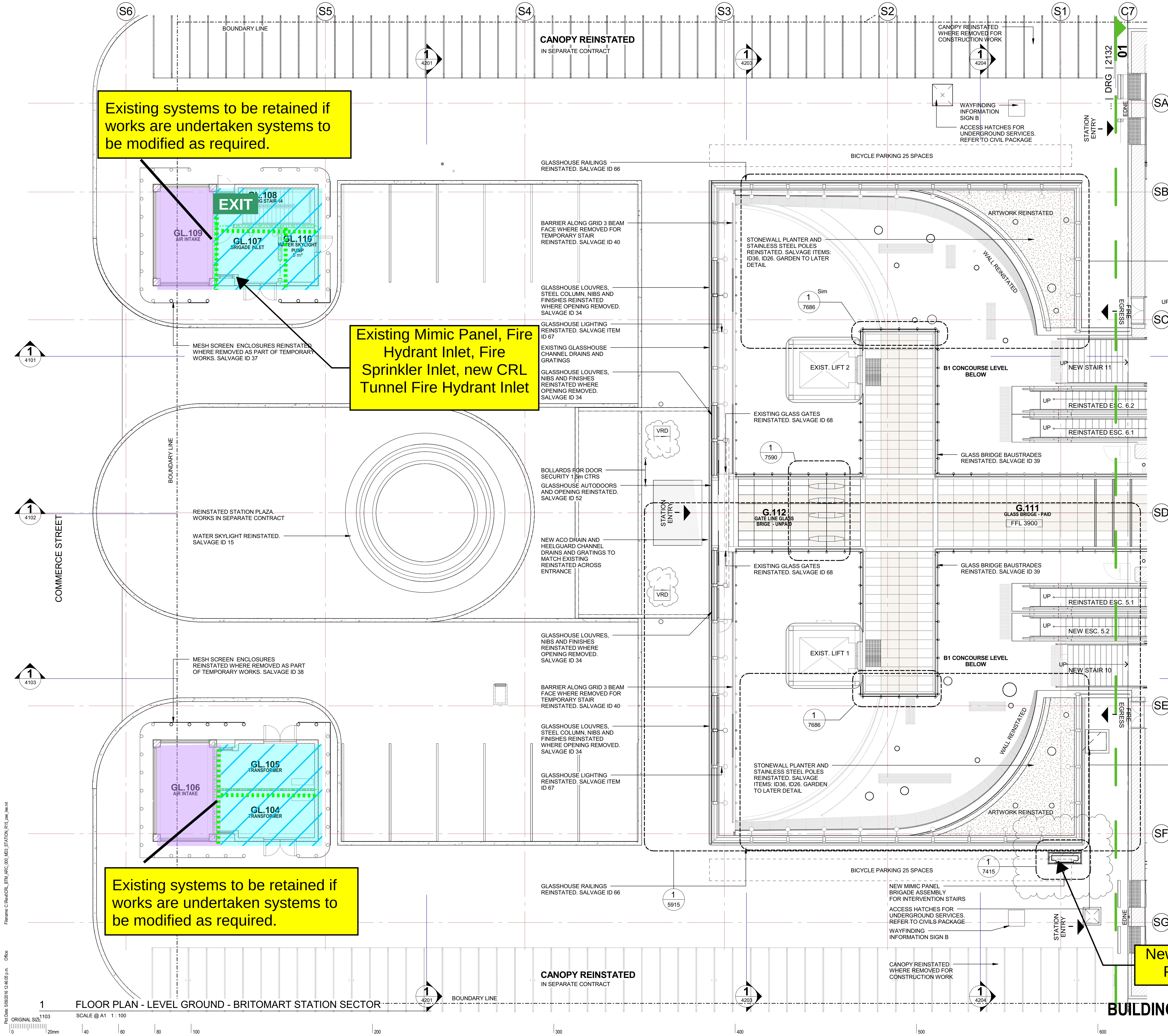

1 FLOOR PLAN - LEVEL GROUND - BRITOMART STATION SECTOR

SCALE @ A1 1 : 100

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
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- HELP POINT — Public Help Point

aurecon GRIMSHAW
MOTT MACDONALD
Jasmax
ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
A	31/08/15	FOR COORDINATION	
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE: As indicated
SIZE: A1

DETAILED DESIGN
NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes
DATE

PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
BRITOMART STATION - PERMANENT WORKS - FLOOR PLAN - LEVEL GROUND

DOCUMENT

BUILDING CONSENT

PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
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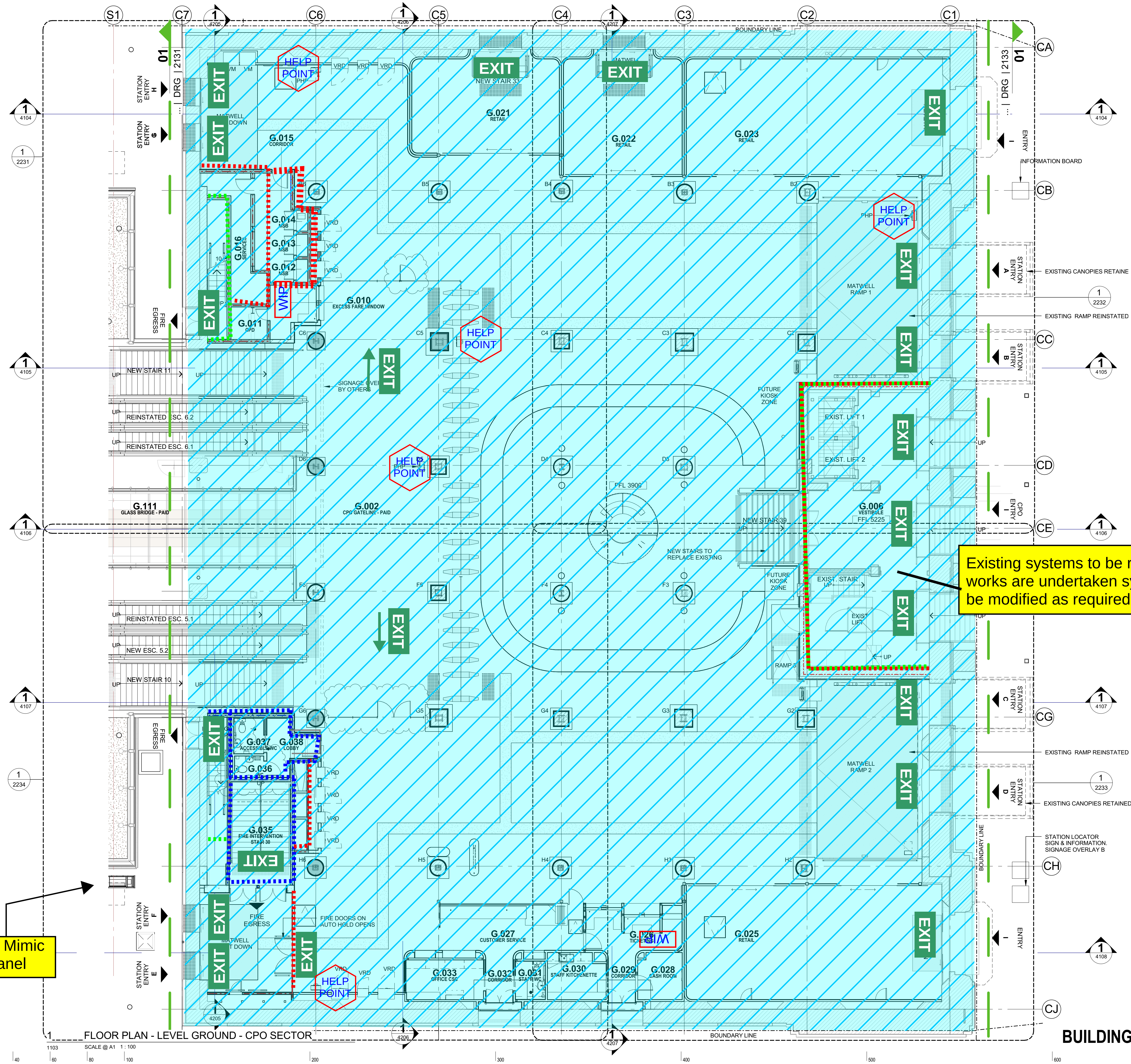


Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
- Area protected by gas suppression system
- EXIT — Indicative Exit Sign Locations
- WIP — Warden Intercom Point
- MCP — Manual Call Point
- HELP POINT — Public Help Point

FOR ALL STRUCTURAL STEELWORK REFER TO STRUCTURAL ENGINEER'S DRAWINGS FOR VERIFICATION OF MEMBER SIZES

aurecon GRIMSHAW
MOTT MACDONALD Jasmax ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
A	31/08/15	FOR COORDINATION	
B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE: As indicated | SIZE: A1 | DETAILED DESIGN NOT FOR CONSTRUCTION

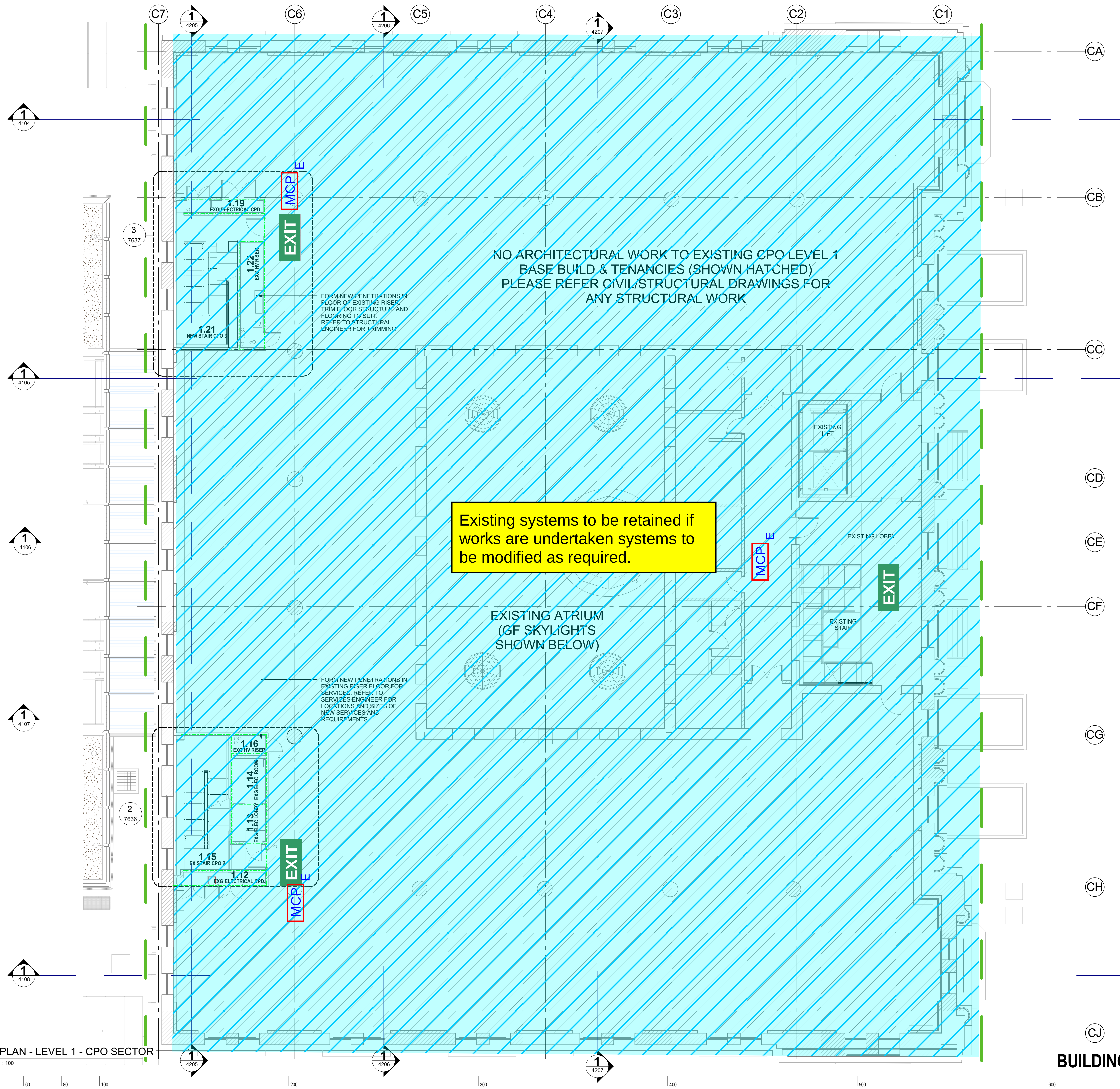
DRAWN: Jasmax
APPROVED — DATE
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
Liam Wythes

PROJECT: AUCKLAND CITY RAIL LINK EC1 BRITOMART & LOWER QUEEN ST.

TITLE: CHIEF POST OFFICE (C.P.O.) - PERMANENT WORKS - FLOOR PLAN - LEVEL GROUND

BUILDING CONSENT

PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
CRL	BTM	ARC	000	DRG	2132	E



1 FLOOR PLAN - LEVEL 1 - CPO SECTOR

SCALE @ A1 1 : 100

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
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aurecon GRIMSHAW MOTT MACDONALD Jasmax ARUP

CLIENT

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E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE	SIZE
As indicated	A1

DETAILED DESIGN
NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes DATE

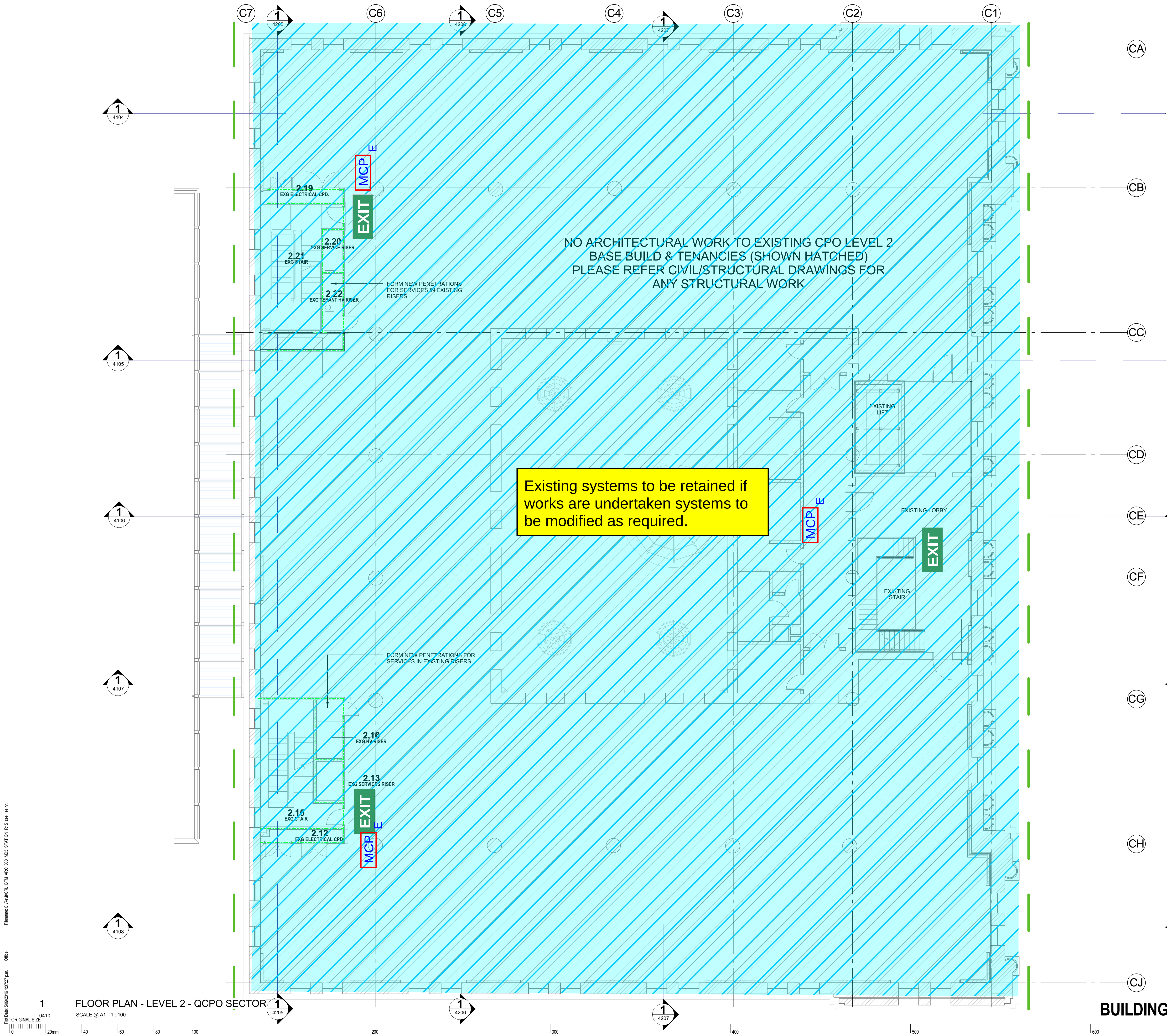
PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
CHIEF POST OFFICE (C.P.O.)
- PERMANENT WORKS -
FLOOR PLAN - LEVEL 1

BUILDING CONSENT

DOCUMENT

PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
CRL	BTM	ARC	000	DRG	2142	E



Arup Markup Legend

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- FRR 120 Minutes
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aurecon GRIMSHAW MOTT MACDONALD Jasmax ARUP

CLIENT

REV	DATE	REVISION DETAILS	APPROVAL
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B	23/09/15	FOR COORDINATION	
C	19/10/15	FOR COORDINATION	
D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE	SIZE	
As indicated	A1	DETAILED DESIGN NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes
DATE

PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
CHIEF POST OFFICE (C.P.O.)
- PERMANENT WORKS -
FLOOR PLAN - LEVEL 2

BUILDING CONSENT

DOCUMENT

PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
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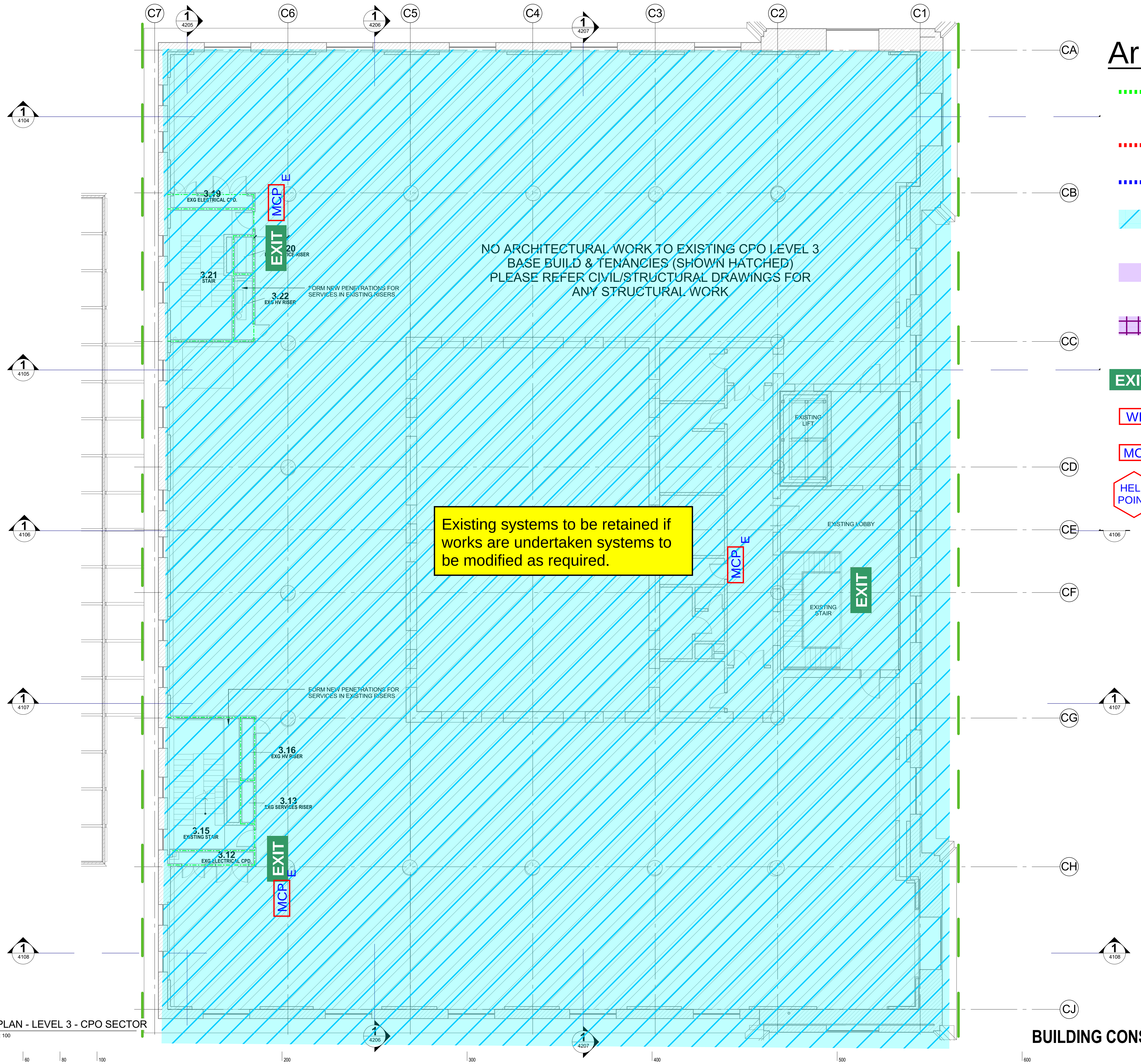

1 FLOOR PLAN - LEVEL 3 - CPO SECTOR
0410 SCALE @ A1 1 : 100

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
- Area protected by gas suppression system
- EXIT — Indicative Exit Sign Locations
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MOTT MACDONALD
Jasmax
ARUP

CLIENT

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D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE: As indicated
SIZE: A1
DETAILED DESIGN
NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes
DATE

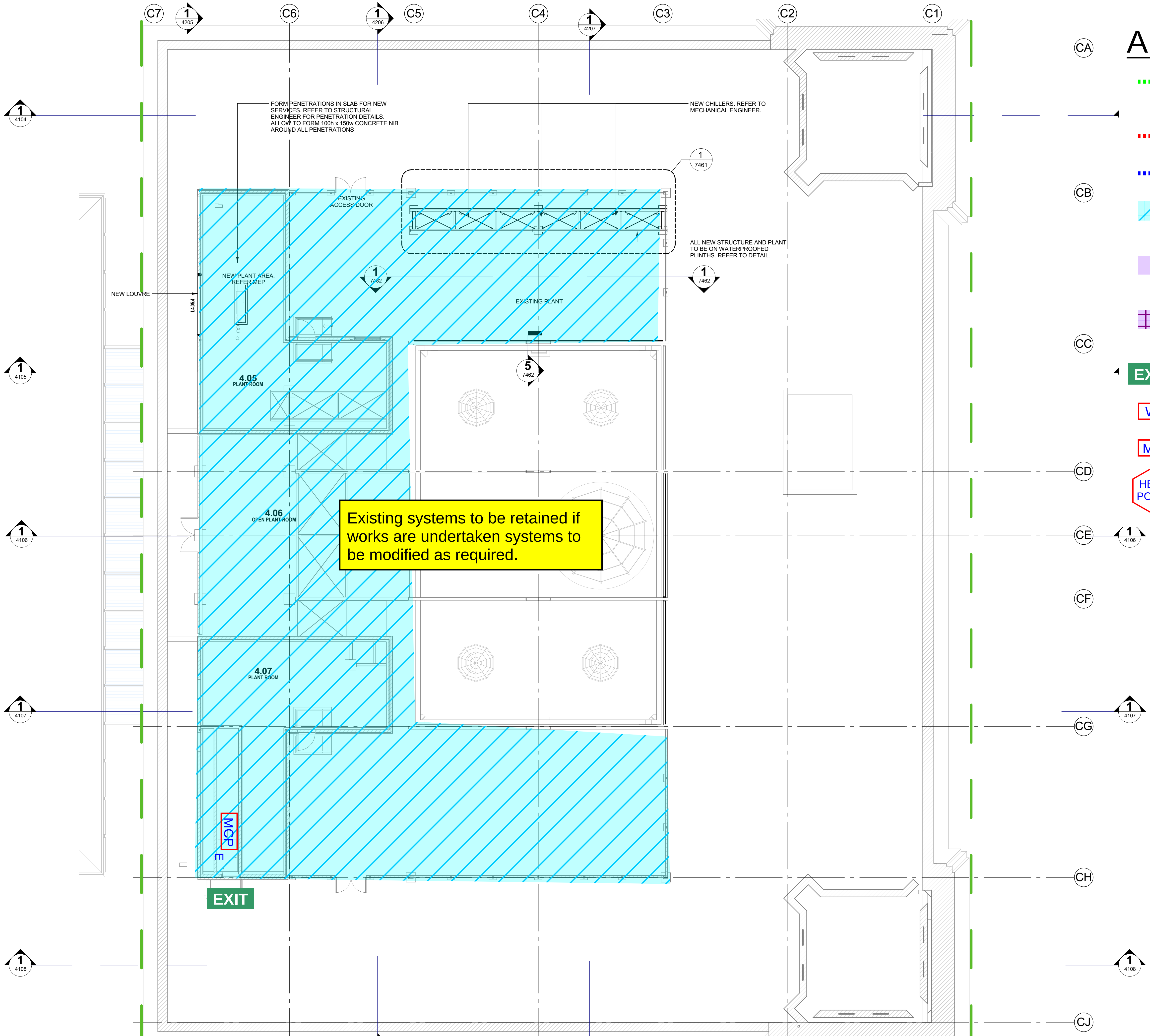
PROJECT
AUCKLAND CITY RAIL LINK
EC1 BRITOMART & LOWER QUEEN ST.

TITLE
CHIEF POST OFFICE (C.P.O.)
- PERMANENT WORKS -
FLOOR PLAN - LEVEL 3

BUILDING CONSENT

DOCUMENT

PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
CRL	BTM	ARC	000	DRG	2162	E



1 FLOOR PLAN - LEVEL PLANT ROOF - CPO SECTOR

1104 SCALE @ A1 1 : 100

Arup Markup Legend

- Existing Fire Rating to be retained
- FRR 60 Minutes
- FRR 120 Minutes
- Area sprinkler protected in accordance with NZS4541
- Detection in accordance with NZS4512
- Area protected by gas suppression system
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aurecon GRIMSHAW MOTT MACDONALD Jasmax ARUP

CLIENT

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D	18/12/15	PERMANENT - DETAIL DESIGN 100%	Liam Wythes
E	02/09/16	BUILDING CONSENT	Liam Wythes

SCALE: As indicated | SIZE: A1

DETAILED DESIGN NOT FOR CONSTRUCTION

DRAWN: Jasmax
DESIGNED: Chris Jack / Martin Walton
CHECKED: Martin Walton
APPROVED: Liam Wythes — DATE

PROJECT: AUCKLAND CITY RAIL LINK EC1 BRITOMART & LOWER QUEEN ST.

TITLE: CHIEF POST OFFICE (C.P.O.) - PERMANENT WORKS - FLOOR PLAN - LEVEL PLANT ROOF

BUILDING CONSENT

DOCUMENT

PROJECT	ZONE	DISCIPLINE	ELEMENT	TYPE	SHEET	REVISION
CRL	BTM	ARC	000	DRG	2172	E

Appendix B – ASET versus RSET Introduction

Introduction

This section presents a quantitative timeline assessment of the Available Safe Egress Time (ASET) compared with the Required Safe Egress Time (RSET) for occupants within Britomart Transport Centre.

As this is an existing building, compliance will be to Section 112 of the Building Act 2004, such that conditions will be compared to those as previously assessed within the 2006 consent. New Zealand Building Code C Clauses Performance Requirements C3.8, C3.9, C4.3 will be demonstrated as nearly as reasonably practicable by an ASET versus RSET assessment as outlined in the FEB.

The calculation of ASET is based on smoke modelling of the nominated design fires in the building to observe the tenability and general conditions, utilising computational fluid dynamics (CFD). The value of ASET is defined as the time at which 'untenable' conditions occur in the relevant evacuation route, where 'untenable' conditions are defined as described below.

The value of RSET is calculated using accepted methods of modelling occupant movement. It is defined as the time required for all occupants to completely evacuate from the location under consideration to a point of safety.

The acceptance criterion for occupant safety is:

ASET/RSET > factor of safety

The required factor of safety for the assessments of the various areas will be:

- 1.5 for base case analyses (i.e., when assessing with all systems operating as designed); and
- 1.0 for sensitivity or redundancy analyses (i.e., where system failures, relative low-probability events, such as exhaust fan failure is included in the analysis).

Available Safe Egress Time – Modelling Parameters

Fire Dynamics Simulator (version 5) software is a CFD model developed by the National Institute of Standards and Technology (NIST) in the USA. The FDS model has been developed specifically for application in fire effects and smoke spread modelling, solving numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally induced flows appropriate for smoke and heat transport in fires.

As the design process was underway before the release of FDS6, use of FDS5 was retained throughout the current analysis. Furthermore, previous studies of Britomart Transport Centre utilise version 5, therefore it is preferable to provide version consistency between the models for which we are comparing results in order to assess comparative levels of safety.

Details relating to the software can be found on the website http://firemodels.github.io/fds-smv/.

All models are approximations of reality and include assumptions and simplifications that result in model limitations. The main assumptions and subsequent limitations relevant to this specific project are considered to be:

Grid Resolution Dependence

If the computational grid is not sufficiently fine relative to the phenomena of interest being modelled, then the smoke flow will not be adequately represented and temperature gradients may be averaged over large volumes.

To overcome this issue, a manually refined cell structure will be implemented, concentrating the finer grid resolution in the areas of interest where the main mixing and entrainment occur and where steep temperature gradients can be expected, i.e. the fire plume region.

As discussed in the FDS Users Guide, for simulation involving buoyant plumes, a measure of how well the flow field is resolved is given by the non-dimensional expression $D^*/\delta x$, where D^* is a characteristic fire diameter. The formula for determining the characteristic fire diameter and resulting maximum recommended grid resolutions in the fire plume region is shown below:

$$D^* = \left(\frac{Q}{\rho_\infty T_\infty c_p \sqrt{g}} \right)^{2/5}$$

δx is the nominal size of a mesh cell. The quantity D*/δx can be thought of as the number of computational cells spanning the characteristic diameter of the fire. The more cells spanning the fire, the better the resolution of the calculation. As an example, in the mesh sensitivity study, the D*/δx values ranged from 4 to 16. These values were used to adequately resolve plume dynamics, along with other geometrical characteristics of the model as well.

A parametric analysis was carried out to determine appropriate mesh dimensions for a nominal 5 MW fire. D*/δx values of 4 and 8 have been investigated. Plume temperatures and velocities predicted in FDS using meshes with the resulting dimensions were compared to results from established correlations by Heskestad. For the fire sizes of interest, it was found that D*/δx =8 results were most consistent with the correlations, giving an absolute relative error under 20%.

The following cell sizes have been used based upon this review:

- Primary domain: maximum cell dimension = 0.2 m
  (D*/δx = 8 to 12 for 4 and 10 MW fires, respectively)
- Secondary domains: maximum cell dimension = 0.4 m

Cell aspect ratios within the primary mesh have been kept as close to 1:1:1 as possible. In secondary domains, cell size ratios up to 2:2:2 (as compared to the primary mesh) have been permitted.

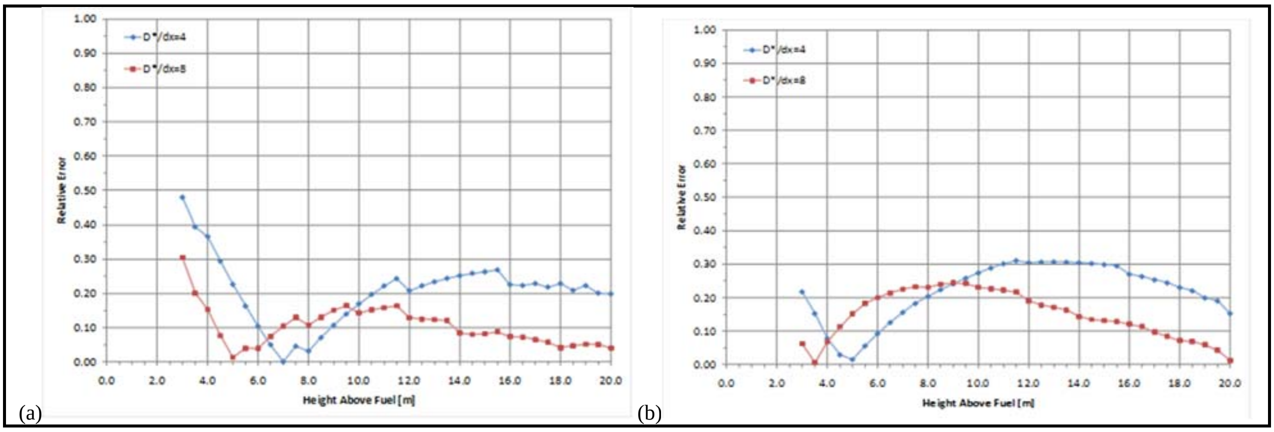


Figure 1: . Relative error comparing FDS predictions to correlations of Heskestad for (a) centerline plume temperature and (b) centerline plume velocity for varying *D*/δx* at a heat release rate per unit area of 750 kW/m^2.

Fire Spread

The modelling of flame spread in large buildings is associated with potentially large uncertainties and is therefore not recommended. Instead the fire heat release rate time history, including the radiative fraction, has been prescribed in the input to the model.

Fire Product Yield & Lower Limit Combustion

Production of fire products, such as soot, must be prescribed in the input to the model together with the heat release rate time history. Subsequently, the fire products yield do not increase for under-ventilated fires as would be expected in real fires. FDS also assumes (when run in LES mode) that all fuel will fully combust if the oxygen concentration is greater than 15% irrespective of the smoke temperature. These assumptions are not considered to affect the validity of the FDS model when the fire is well-ventilated and adequate supply of oxygen is available for complete combustion.

Acceptance Criteria

NZBC Clause 4.3: The evacuation time must allow occupants of a building to move to a place of safety in the event of a fire so that occupants are not exposed to any of the following:

a) *fractional effective dose of carbon monoxide greater than 0.3:*

b) *a fractional effective dose of thermal effects greater than 0.3:*

c) *conditions where, due to smoke obscuration, visibility is less than 10 m except in rooms of less than 100 m² where visibility may fall to 5 m."*

This assessment will consider the following, as per Request for NZ Building Code Clarification – NZBC Clause C4.3:

Certain locations within the station will be excluded from the Clause 4.3(c) criterion (i.e., visibility may fall below 10 m).

These locations are unlikely to be relevant in terms of occupant evacuation. It will be considered that a location is excluded from this clause if:

The location is not on an evacuation route, or

A. The location is within the fire source, or within close proximity to the fire source. Occupants in these locations are expected to move away from these locations due to the immediate danger presented by the fire, or

B. An alternative evacuation route is provided which remains tenable for the length of time necessary for occupants to achieve evacuation by this alternative means.

Furthermore, for locations on evacuation routes which do experience local visibility of less than 10 m, it may still be deemed compliant with C4.3(c) if:

C. The visibility falls below 10 m only at a time after all occupants are expected to have passed the location in making their escape, or

D. Visibility only falls below the 10 m criterion momentarily. Provided that the 30-second average visibility remains greater than 10 m, it will be considered that the location still complies with clause C4.3(c).

This exclusion is recognised in NFPA130 in Appendix B Clause B.2.2:

> *"… the application of tenability criteria at the perimeter of the fire is impractical. The zone of tenability should be defined to apply outside the boundary away from the fire. This distance is dependent on fire heat release rate, the fire smoke release rate, local geometry, and ventilation and could be as much as 30 m."*

<u>Fractional Effective Dosage (FED)</u>

The Fractional Effective Dosage (FED) is calculated as per ISO 13571 (Life threatening components of fire – Guidelines for the estimation of time to compromised tenability in fires.

FED_{CO}

For carbon monoxide:

$$t_{CO} = \frac{35\ 000}{\varphi_{CO}}$$

where φ_{CO} is the average concentration, expressed in $\mu l \cdot l^{-1}$, of CO over each time increment, Δt, in minutes.

NOTE The compromising tenability dose, $(C \cdot t)$, for CO of 35 000 $\mu l \cdot l^{-1}$min was obtained from experiments on juvenile baboons subjected to an escape paradigm[3]. Using the Stewart–Peterson equation[4], a dose of 35 000 $\mu l \cdot l^{-1}$min would produce approximately 30 % blood carboxyhaemoglobin saturation in humans having average adult body weight and a respiratory minute volume of 20 l/min.

$FED_{Thermal}$

$$X_{FED} = \sum_{t_1}^{t_2} (1/t_{Irad} + 1/t_{Iconv}) \Delta t \quad (11)$$

In areas within an occupancy where the radiant flux to the skin is under 2,5 kW·m^{-2}, the term ($1/t_{Irad}$) in Equation (11) is set at zero.

Note: a radiant flux of 2.5 kw/m^2 corresponds roughly to an upper layer temperature of 200°C. Radiant heat flux (to the skin) is measured by way of 'devices' in the FDS model at 2.0 m above floor level for areas remote from the fire within the Glasshouse and CPO.

For clothed occupants

$$t_{Iconv} = (4,1 \times 10^8) T^{-3,61}$$

Where:

T Temperature at 2.0 m above floor level (°C)

Visibility

Visibility is calculated within FDS based on smoke obscuration; a specific extinction coefficient of 8700 m²/kg and a visibility constant of 2.0, as appropriate to reflective surfaces such as walls; have been applied in these calculations.

It is recognised that people can continue to evacuate when visibility falls below 10 m, as expressed in the Request for NZ Building Code Clarification – NZBC Clause C4.3, in particular item D is outlined below.

D. Visibility only falls below the 10 m criterion momentarily. Provided that the 30-second average visibility remains greater than 10 m, it will be considered that the location still complies with clause C4.3(c)

This is supported by ISO 13571 which notes that smoke obscuration, alone, should not necessarily compromise tenability. This is based on temperatures near ambient and at altitude where reduced oxygen is not a consideration. It also differentiates between early impacts on reduced visibility that cause a behavioural response, compared to a reduction in visibility that results in disorientation.

Further PD 7974: Part 6 suggests that in small rooms an acceptable minimum visibility is 5 m, with the implication that the reduction of visibility is acceptable due to occupants having less distance to determine locations of exits and to see exit signs.

Where fire scenarios present results that show visibility falls below the nominated 10 m criterion during the evacuation phase along the evacuation path, 30-second average visibility as well as the following variables will be considered: temperature of smoke, location of visibility drop relative to the complexity of the egress path, location of signs, other evacuating occupants, and the distance/ depth of the areas where the visibility drops relative to the drop in visibility.

For example if the visibility drops to 5 m, but it only drops for a distance of 2 m along the egress path, or the next sign or evacuation element (first step in a stair way, or exit doorway) is less than 5 m away, of there is queuing and occupants are following other occupants who are past the areas where the visibility drops, occupants are considered able to continue evacuating in these circumstances.

Required Safe Egress Time - Parameters

The Required Safe Egress Time (RSET) can be expressed in the following equation:

$$RSET = (t_d + t_n + t_{pre}) + (t_{trav} \text{ or } t_{flow})$$

Where:

t_d is the detection time

t_n is the notification time

t_{pre} is the pre-movement time

t_{trav} is the movement time

t_{flow} is the flow time

This formulation is based on the equation presented in the SFPE Handbook (3-13).

Each of these components are individually discussed and assessed below.

Note: Within Britomart Transport Centre, occupant evacuation times are to be calculated based on the methodology and parameters (flow time and travel speeds) promulgated in NFPA 130.

Alarm Time ($t_d + t_n$)

Analysis of the alarm time within such a building is difficult to predict because (in reality) it could be via any or a combination of the following (depending on fire location):

- Smoke detector activation; or
- Sprinkler activation; or
- Visual detection by station staff or other occupants near the fire.

The alarm time is the time from fire ignition to detection and the time for the detection to notification. For automatic systems where the occupant warning is activated by the detection system t_d to t_n is considered instantaneous unless there is a specified delay. For visual detection, t_d and t_n have been considered in combination. It is noted that with visual detection there are also other cues such as olfactory cues during the incipient phase (i.e smouldering, early growth stages of a fire), which are not considered in the fire modelling.

For the assessment, the alarm time has been based on visual detection due to the highly controlled nature of the space. Whenever the building is occupied there will be station staff and security staff manning the area, in addition there is CCTV coverage which is monitored by the MC.

Within Britomart Transport Centre occupant alarm times are based on the train timeline events. These assumptions have been presented to, and agreed to by the project stakeholders. Refer Appendix D and E.

Pre-movement Time

Pre-movement time depends on two parts; coping time and recognition time. During the coping time, occupants will become aware of the situation and in the recognition time they will decide how to react.

Within the CPO and Temporary Entrance, as recommended in PD 7974:Part 6, in a building where occupants are considered awake, alert and unfamiliar with the building, the pre-movement time in the enclosure of fire origin is **30 seconds** and the areas remote from the enclosure of fire origin is **60 seconds**, provided that the building is provided with voice alarm.

In addition, staff can initiate and direct occupants during evacuation which will further reduce coping time and recognition time.

Within Britomart Transport Centre occupant pre-movement times are based on the train timeline events. These assumptions have been presented to, and agreed to by the project stakeholders. Refer Appendix D and E.

Travel Time (t_{trav} or t_{flow})

The response to a fire cue and the efficiency of evacuation are dependent on the capability of occupants. The occupants are assumed to be representative of the broad population. However, special procedures will be developed for the evacuation of mobility impaired occupants.

Within the CPO and Temporary Entrance, the travel time has been calculated following the methodology as outlined in SFPE Handbook (3-13).

Within Britomart Transport Centre occupant movement times are to be calculated based on the methodology and parameters (flow time and travel speeds) promulgated in NFPA 130. Refer Appendix D and E.

Appendix C
Temporary Entrance Assessment

Acceptable Solutions Assessment

Risk Group & Occupant Load

The areas within the temporary accommodation buildings to the north and south of the Temporary Entrance only contain ancillary functions to the Temporary Entrance.
Table 1: Risk Groups within the Temporary Entrance

Location	Risk Group	Escape Height [m]	Relevant Acceptable Solution
Temporary Entrance	CA	0 m	C/AS4
Temporary Block – North	CA*	0 m	C/AS4
Temporary Block – South	CA*	0 m	C/AS4

* Ancillary functions to the CA purpose group (i.e. toilets/ rubbish room/ services enclosures/ ticketing enclosures and associated rooms)

The primary risk group is CA.

Table 2: Temporary Entrance Occupant Load

Location	Area [m²]	Occupant Densities [m²/person]	Occupant Load
Temporary Entrance	**755**		
• Plaza Concourse	684	3.5	196
• Retail Tenancy	32	3.5	9
• Customer Service	39		
o Office	8.9	10	1
o FOH area	30.1	3.5	9
Temporary Block – North	**141**	(intermittently occupied)	-
Temporary Block – South	**135**		
• Ticket Office	18.4	No. seats	3
• Office Areas	26.6	10	3
• Retail Tenancy	53	3.5	15
• Ancillary	37	-	-
Total	**1,031**		**236 persons**

\- Occupant load not included for areas such as exit ways, services cupboards/rooms or sanitary facilities that are used intermittently by people already counted elsewhere in the building.

* As a stand-alone building the Plaza concourse is treated as pedestrian circulation areas including malls and arcades. As the main entrance to Britomart Transport Centre the Temporary Entrance is assessed as summarised in the RSET Section below.

The total occupant load of the Temporary Entrance is calculated to be 236 persons.

Compliance with Acceptable Solutions

Assessment against the Acceptable Solutions C/AS4 determined the following requirements for the Temporary Entrance, as tabulated in Table 3Table 3.

Table 3: Temporary Entrance C/AS4 Fire Safety Requirements

Fire Safety Measure	Description		Compliance Achieved/ Comment
Fire Safety Precautions			
Type of System	***System Description***	***Standards for Installation***	
6	Fire sprinkler system	NZS 4541	A Type 6 system may be substituted for a Type 4 system. Occupant load is < 500 and Temporary Entrance is a single storey building. Electrical rooms which are non-sprinkler protected areas due to safety reasons will be protected by a smoke detection and alarm system in accordance with NZS 4512.
9	Smoke control for air handling systems	AS/NZS 1668.1	N/A: Temporary Entrance is a single fire compartment. Plaza concourse is naturally ventilated, which also functions as natural smoke exhaust – due to integration with Britomart Transport Centre which is over and above C/AS4 requirements. Note as per AS 1668.1 Clause 5.2.3 Individual air-handling systems having a total aggregate supply airflow rate of not more than 1000 L/s, located in and serving a single fire compartment, may continue to operate.
18	Fire hydrant systems for buildings	NZS 4510	N/A: Fire service can park their vehicles on 3 of the 4 sides of the Temporary Entrance with hose runs less than 75 m. Type 18 system is required unless the Fire Service hose run distance from Fire Service vehicular access to any point on any floor is less than 75 m.
Fire Resistance Ratings	FRR 30 minutes	Life rating	Fire sprinkler system provided (otherwise 60 minutes required); *Note: structural elements in a single storey building need not be fire rated.*
	FRR 60 minutes	Property rating	Fire sprinkler system provided (otherwise 120 minutes required) *Note: structural elements in a single storey building need not be fire rated.*
F6/AS1	Emergency Lighting	F6/AS1	Plaza concourse requires emergency lighting as it is *"an occupied space designed for an occupant load of more than 250 people including all escape routes serving that space"* Illuminance of no less than 1.0 lux throughout. Duration 90 minutes - due to integration with Britomart Transport Centre which is over and above F6/AS1 requirements. All other requirements to comply with F6/AS1.
F8/AS1	Signs	F8/AS1	All escape routes shall have signs complying with NZBC F8
Means of Escape			
Number of escape routes	Minimum of 2 required of occupant loads up to 500.		Yes – Multiple exits provided, 3 main exits plus retail tenancies and customer service tenancy have additional exits direct to exterior.
Height	Clear height to be no less than 2,100 mm.		Yes – based on architectural drawings.

Fire Safety Measure	Description	Compliance Achieved/ Comment
	Door opening to have a clear height of no less than 1955 mm.	
Width	Based on 7 mm/person: 1,631 mm required Accessible routes required to have a minimum width of 1200 mm for horizontal travel Provision for unusable escape routes not required given sprinkler protected building	Yes – based on architectural drawings. Aggregate egress width of 16.9 m from the Plaza Concourse. In addition each retail tenancy has an exit directly to outside of 2.0 m and the customer service tenancy has a 1.0 m exit directly to outside. Additional exit width provided for integration with Britomart Transport Centre as discussed in the RSET Section below.
Escape route length	Type 6 System installed permits: • Dead end open path shall not exceed 40 m • Total open path shall not exceed 100 m	Yes - as shown in Appendix A • Maximum dead end open path (from toilets) 12.6 m. • Maximum total open path 32.6 m.
Doors and locking devices	Doors within escape routes to comply with C/AS4 3.15 requirements	Yes - to be installed to comply with requirements. All final exit doors from Plaza Concourse to be open during Britomart Transport Centre opening hours. Panic hardware installed on one double-leaf set of doors per exit.
Internal Fire Spread		
Temporary Entrance	The Temporary Entrance is one fire cell except as specified below: • The rubbish room will be a separate firecell with fire separations having an FRR of no less than 60 minutes. • Electrical cupboards, proposed to be un-sprinklered due to safety reasons, will be a separate firecell with fire separations having an FRR of no less than 60 minutes.	Yes - compliance to be achieved in construction Over and above C/AS4 requirements Britomart West access to the Mimic Panel and Fire Brigade inlets, shall be fire separated (30 minutes) from the adjoining retail unit within the Temporary Entrance, as shown in Appendix A.
Internal Finishes	• Wall and ceiling linings • Flooring • Suspended flexible fabrics	Yes - Compliance to be achieved in construction. Over and above C/AS4 requirements Plaza Concourse linings will comply with Exitway requirements for integration with Britomart Transport Centre as discussed in Section **Error! Reference source not found.**4.
External Fire Spread		
Unprotected area	100 percent of the external wall is permitted to be unprotected when located at least 10 m to a relevant boundary.	Yes – bounded by roads on three sides West wall of Temporary Entrance is part of the integration with Britomart Transport Centre as discussed in Section Error! Reference source not found.4.
Exterior surface finishes	Distance to the relevant boundaries is greater than 1 m and the building height is less than 7.0 m, and the Temporary Entrance is sprinkler protected.	No external wall requirements

Fire Safety Measure	Description	Compliance Achieved/ Comment
Other		
Fire service vehicular access	N/A	As shown in Appendix A; Temporary Entrance bounded by public roads on 3 sides.
Management and Maintenance	All active and passive fire safety systems shall be maintained in accordance with the Compliance Schedule	Yes - All fire safety systems encompassed within the Britomart Transport Centre Compliance Schedule

Conclusions

This assessment shows that the proposed Temporary Entrance at Britomart Transport Centre will achieve compliance with the NZ Building Code Clauses C1 – C6 for Protection from Fire as required by the NZ Building Act by meeting Acceptable Solution C/AS4, for buildings with public access and educational facilities (Risk Group CA).

Analysis

This section presents a quantitative timeline assessment of the Available Safe Egress Time (ASET) compared with the Required Safe Egress Time (RSET) for occupants within the Temporary Entrance building.

In isolation, the Temporary Entrance complies with C/AS4 requirements. The analysis has therefore been conducted for completeness as the Temporary Entrance is connected to the Britomart Transport Centre, and will function as the main point of access to and egress from Britomart West during the Enabling Works. It is noted that in the event of fire in the Temporary Entrance, occupants in other areas (the station platforms) will not be evacuating through the area. As such, the Temporary Entrance is only being assessed as base case only without consideration of system failures.

Available Safe Egress Time

The ASET times have been calculated by undertaking CFD modelling of the interconnected parts of the building. The inputs for various parts of these models are summarised below.

Design Fire and Fire Scenarios

The fire scenarios and design fires has been agreed within the design team as part of the FEB process.

Table 41: Design Fire Parameters

Design Fire Parameters	Design Fire 1	Design Fire 2
Design Fire ID	Sprinkler Controlled Fast t^2 Fire	Fuel Controlled Fire
Fire growth rate	Fast t^2 fire	Fast t^2 fire
Sprinkler activation	Calculated via FPETool (verified as conservative with a thermal device in FDS model) RTI - 200 Activation temperature - 68 °C r_{spk} – 2.5 m Ceiling height – 3.5 m T_{act} = 205 seconds	-
HRR	1.9 MW at sprinkler activation 3.3 MW at steady state	3.5 MW as calculated below
Comment	Conservative RTI (200) utilised to permit variations in design. At the time of modelling, layout was yet to be finalised, e.g. concealed fire sprinkler heads, change in retail ceiling height. It also takes into consideration the potential for a faster fire growth rate.	Design Fire size permits 'pop up retail' within the entrance. It is noted the Temporary Entrance is also fire sprinkler protected.

The design fires which consider sprinkler activation are considered to be conservative. It is likely that once sprinklers activate they would typically reduce the fire size and suppress if not possibly extinguish the fire over time. Further, the fuel controlled fire is also expected to decay over time, either due to sprinkler activation or due to the fuel being consumed.

The assumed heat release rate curve for the base case is depicted as follows:

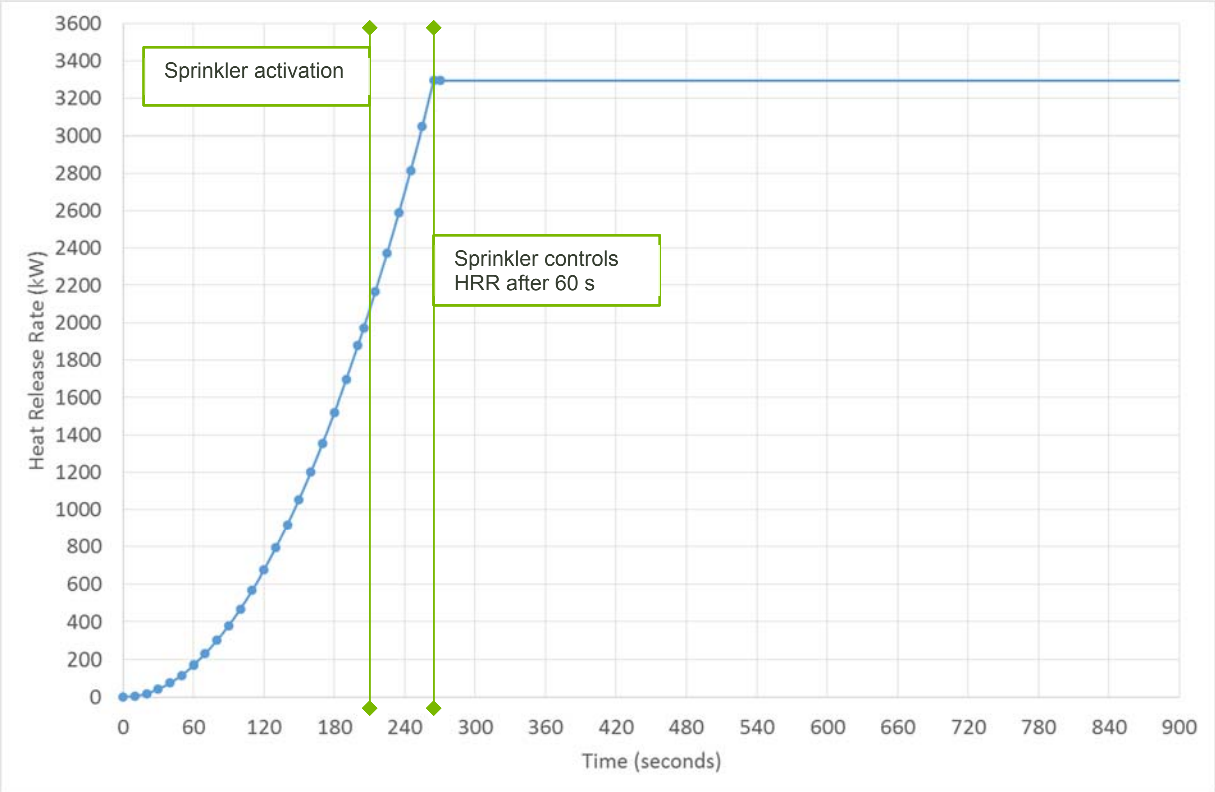


Figure 2: Temporary Entrance Design Fire – Sprinkler Controlled Fast t² Fire

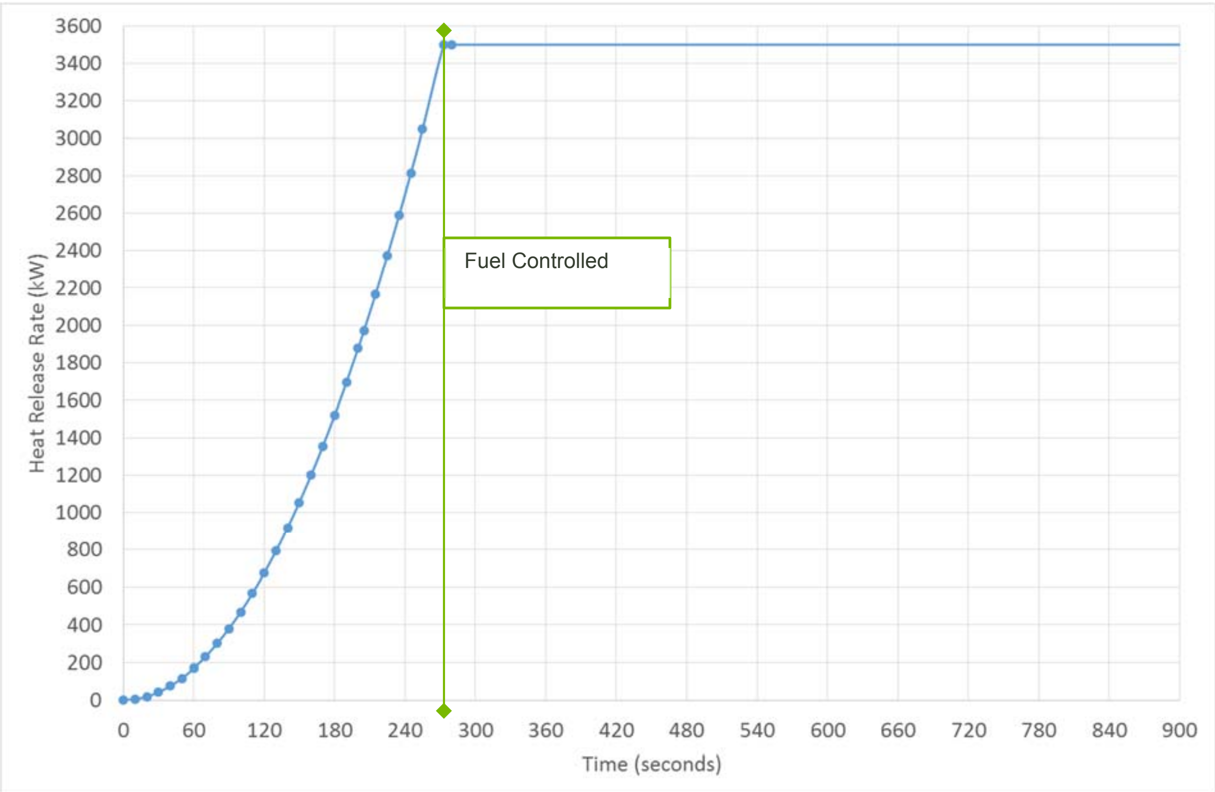


Figure 3: Temporary Entrance Design Fire – Fuel Controlled Fast t² Fire

Refer to Arup Memo dated 3 September 2015 *ACRL – Britomart West Temporary Entrance Fire Strategy* for a detailed assessment of the fuel controlled fire. Key points are summarised herein.

In order to maintain flexibility for the use of the temporary entrance forecourt, Auckland Transport has requested the capability to accommodate ‘pop-up’ retail. Taking into consideration sight lines and pedestrian flow requirements during day-to-day use, the following zones (in green) have been designated (by others) as appropriate for ‘pop-up’ retail with a maximum height of 2.0 m.

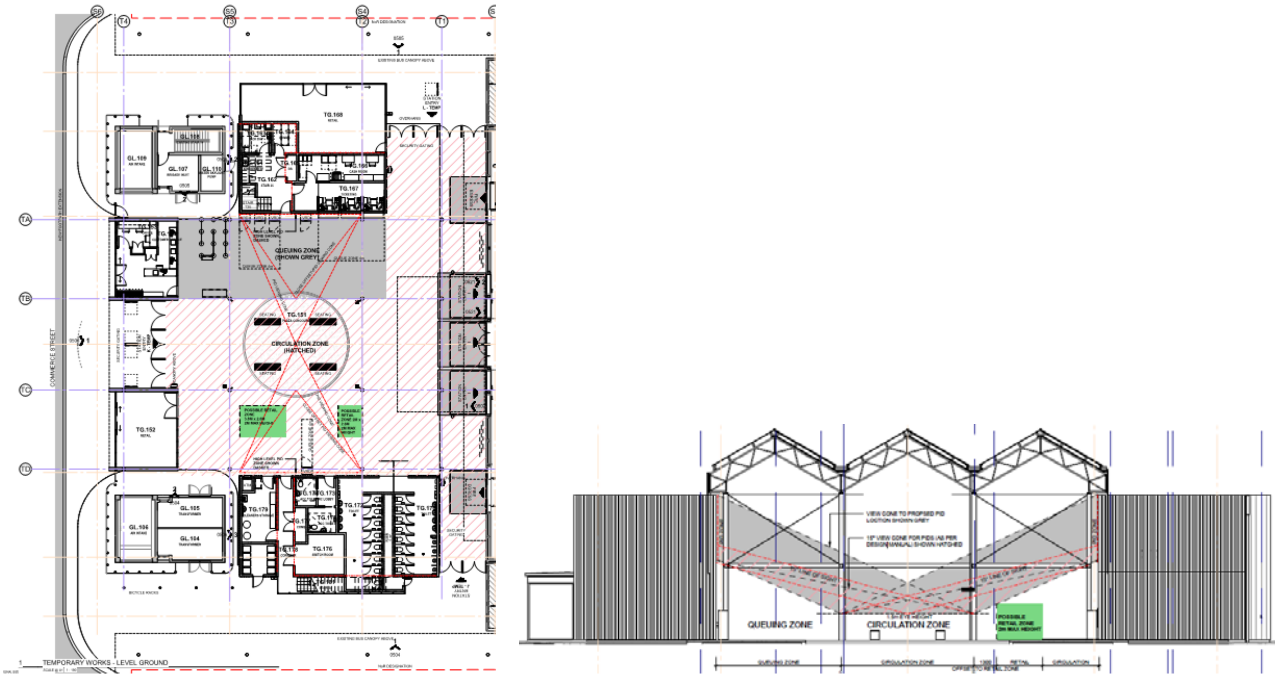


Figure 4: Temporary Entrance, retail zones in green

Through preliminarily assessment and stakeholder consultation, it was determined that these areas will be constrained so that fuel load/fuel packet sizes conform to the agreed Temporary Entrance design fire of 3.5 MW.

The resulting size of the retail units is based on the Heat Release Rate Per Unit Area (HRRPUA) for different occupancies in Table 10.3 of CIBSE Guide E. The values specified for shops/retail occupancies is HRRPUA = 550 kW/m². Based on a design fire size of 3.5 MW, the area limit for pop up retail is 6.3m².

Based on ignition occurring when combustible materials are exposed to a radiant heat flux of 10 kW/m², and a 5.0m wide x 2.0m high radiant panel with an average flame temperature of 800°C, each pop up retail unit can be considered a discrete fuel load when separated by greater than 4.5 m.

Accordingly, the maximum aggregate area for ‘pop-up’ retail is 6.3 m², or a maximum of 6.3 m² each where separated by a clear distance of greater than 4.5 m, i.e. no seats, signs, or other combustible items.

It is noted that sprinkler protection of the entire entrance space helps to mitigate a portion of the risk associated with pop-up retail. However, it is still prudent to limit the size of individual fuel packets and the aggregate fuel load within the space to a level consistent with the design fire basis.

The following fire scenarios have been considered within the Temporary Entrance.

Table 52: Fire Scenarios

Fire Scenario	Location	Design Fire	Case	Comments
1	Retail unit opening into the circulation space	Sprinkler Controlled Fast t² Fire	Base Case	Examine a spill plume on the egress paths
2	(Near) Centre of the circulation space	Fuel Controlled Fast t² Fire	Base Case	

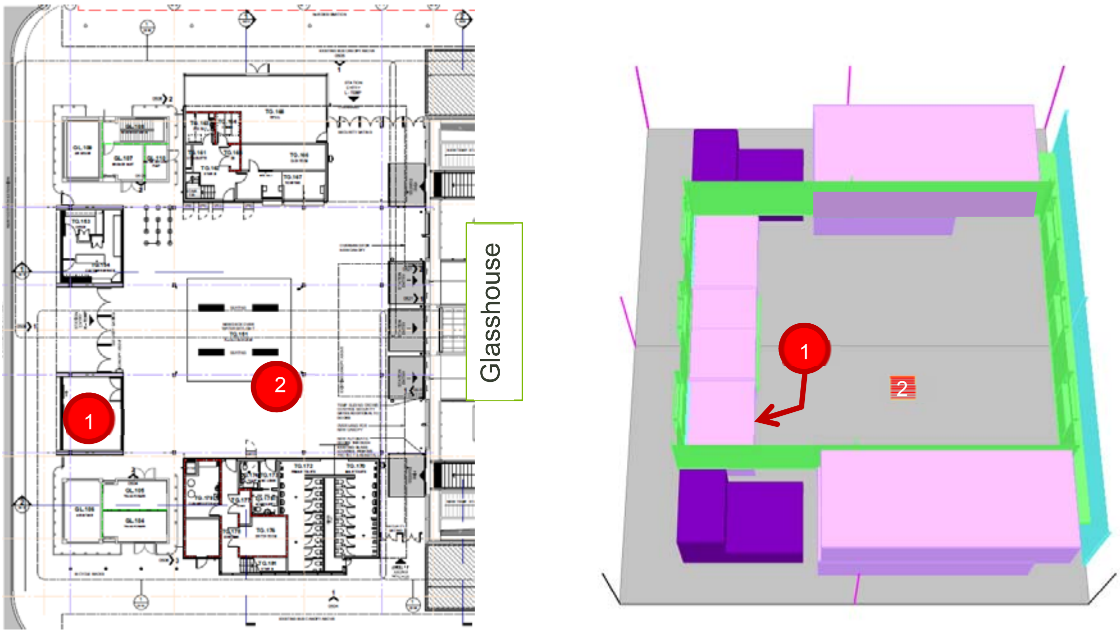


Figure 5: Temporary Entrance – Isometric and FDS model geometry indicating fire location

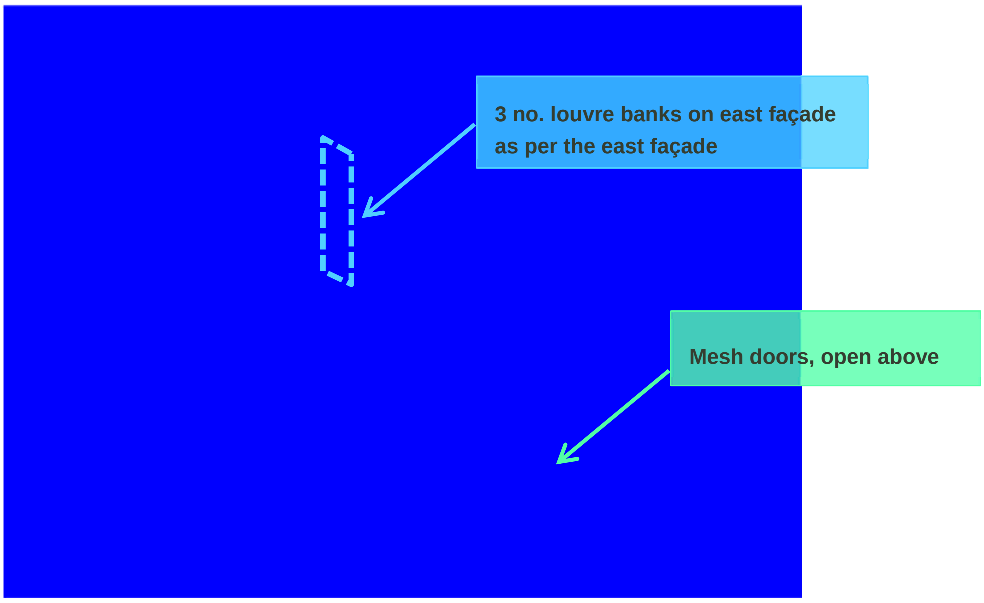


Figure 6: Isometric view of west end of the Temporary Entrance (looking north)

FDS Parameters

Inputs		Comments
Model geometry	As per drawings	Note: During the design process the blocks to the north and south of the Temporary Entrance were reduced from two storeys to single storey. This has minimal/no effect on the modelling results as there were no openings modelled between the Temporary Entrance wall and the roof of the 2nd story of the blocks.
Grid resolution (4 < D*/δx < 16)	0.10 ~ 0.40	Based on Q = 3.5 MW
Mesh size	0.2m x 0.2m x 0.2m	
Simulation time	1200 seconds	
Ventilation / Makeup air	Natural ventilation provided by 3 x louvre banks on west façade and the east façade. Modelled as w 3.8 m x 1.9 m Makeup air provided as per drawings: opening to outside under polycarbonate walls, doors are mesh gates modelled at 70 % free area.	Roof gap between temporary blocks roof and polycarbonate ignored. During the design process the free area of the louvres were altered from those modelled. The effectiveness of the selected louvres were verified against the modelling results – refer Louvre Selection Section in this Appendix
Other Fire Safety Systems	-	It is noted that sprinklers will not be included within the model(s); design fires will simply be modelled to maintain a steady-state HRR shortly after the predicted time of sprinkler activation.
Fuel type	Polyurethane, $C_{6.3}H_{7.1}P_{2.1}N_{1}$	
Soot yield	0.07 kg_{soot} / kg_{fuel}	
CO yield rate	0.04 g/g	
Visibility Factor	2.0	Appropriate for reflective surfaces (e.g., walls)
Heat release rate per unit area (HRRPUA)	HRRPUA = 550 kW/m^2	This is the value for shops/retail occupancies; refer Table 10.3 of CIBSE Guide E.
Heat Flux Devices	25 off, 2.0 m above floor level 4.6 m x 6.0 m grid pattern	

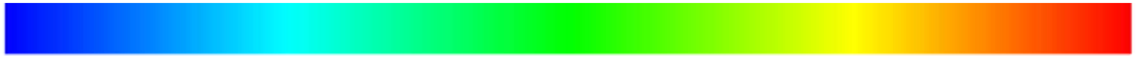
Results

The ASET exceeded the simulation time, as tenability was determined to be maintained for the duration of the model, i.e.1,200 seconds.

For a complete set of the results refer Appendix G.

Temporary Entrance: Fire Scenario 1 – Retail Fire

Visibility



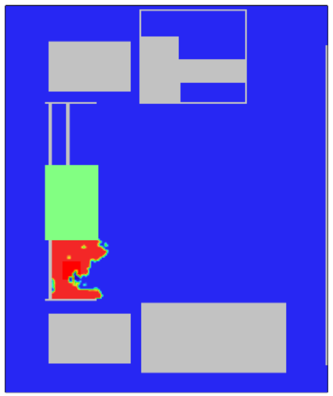
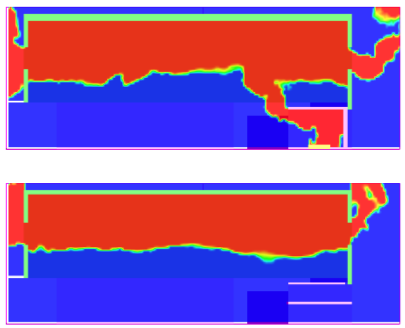
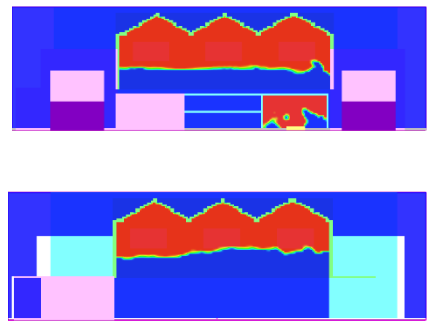
10.0 9.41 8.81 8.21 7.61 7.01 6.40 5.80 5.20 4.60 4.00 m

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (1,200 s).

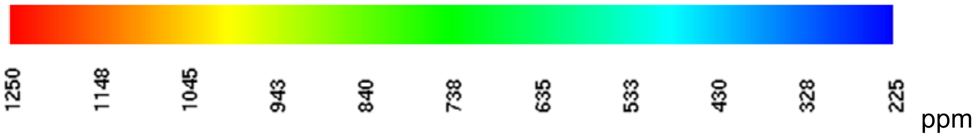
In this fire scenario the tenability is considered to be > 1,200 seconds.

- The natural ventilation maintains the smoke layer height such that tenable conditions are provided throughout the Temporary Entry for the duration of the simulation.

Exits	t = 1,200 seconds	t = 1,200 seconds	t = 1,200 seconds
	 Plan view at 2.0 m above floor level	 Looking north, through the fire and through the centre of the Temporary Entrance	 Looking west, through the fire and through the centre of the Temporary Entrance

Temporary Entrance: Fire Scenario 1 – Retail Fire

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

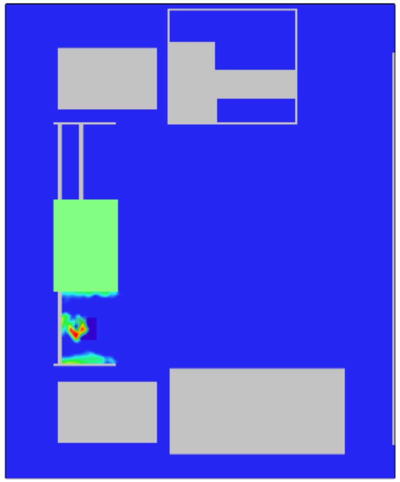
As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

$FED_{CO} = (\varphi_{CO}/35,000)*\Delta t$

$FED_{CO} = (225/35,000)*20$

$= 0.129$ (≤ 0.3 acceptable).

Note, however, that the results do not indicate CO accumulation at a height of 2.0 m. Therefore, the FED_{CO} is likely less than that calculated here.



Temporary Entrance: Fire Scenario 1 – Retail Fire

FED$_{Thermal}$

Tenability limit for FED$_{Thermal}$ is exceeded when the FED$_{Thermal}$ is greater than 0.3

FED$_{Thermal}$ is a function of both radiant heat and convective heat.

Radiant Heat

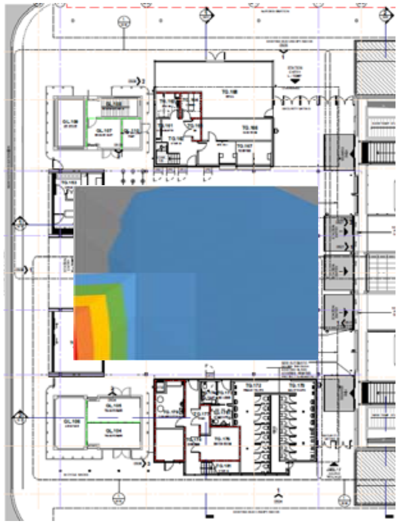
0.00-0.50 0.50-1.00 1.00-1.50 1.50-2.00 2.00-2.50 2.50-3.00

kW/m²

At 2.0m above floor level, in areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds).except within the retail unit. Note 0.42 kW/m² is the background radiant heat flux within the model.

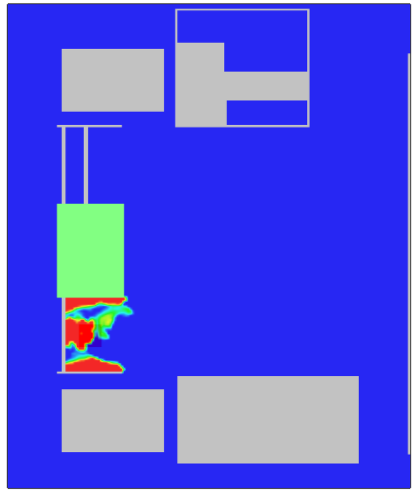
Therefore radiant heat can be discounted in the in FED$_{Thermal}$ calculation.

This also demonstrates the Performance Requirements of C3.8 are achieved as the radiation flux above the required 1.5 m above the floor (2.0 m) does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.



Temporary Entrance: Fire Scenario 1 – Retail Fire

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation, the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.064$ ($\leq$ 0.3 acceptable)

Temporary Entrance: Fire Scenario 2 – Fuel Controlled Fire

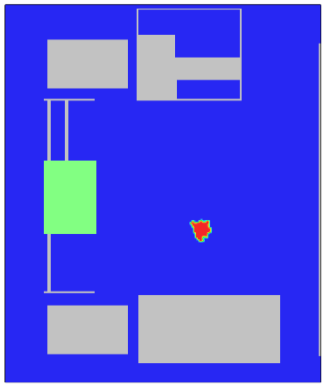
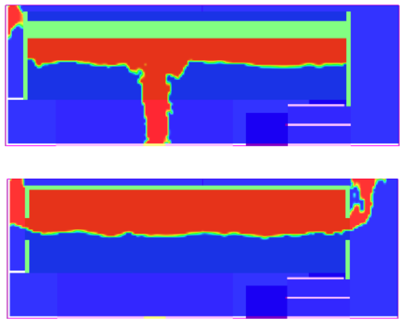
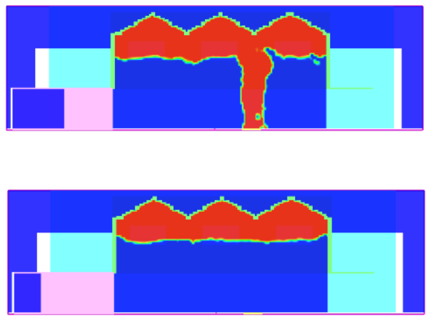
Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (1,200 s).

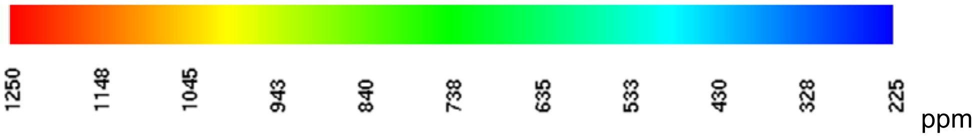
In this fire scenario the tenability is considered to be > 1,200 seconds.

- The natural ventilation maintains the smoke layer height such that tenable conditions are provided throughout the Temporary Entry for the duration of the simulation.

Exits	t = 1,200 seconds	t = 1,200 seconds	t = 1,200 seconds
	 Plan view at 2.0 m above floor level	 Looking north, through the fire and through the centre of the Temporary Entrance	 Looking west, through the fire and through the centre of the Temporary Entrance

Temporary Entrance: Fire Scenario 2 – Fuel Controlled Fire

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

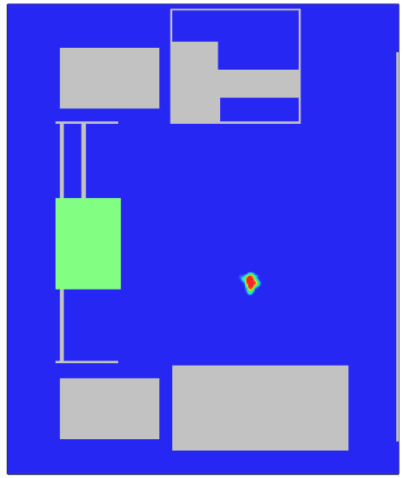
At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

$FED_{CO} = (\varphi_{CO}/35{,}000)*\Delta t$

$FED_{CO} = (225/35{,}000)*20$

$= 0.129$ ($\leq$ 0.3 acceptable).



Temporary Entrance: Fire Scenario 2 – Fuel Controlled Fire

$FED_{Thermal}$

Tenability limit for $FED_{Thermal}$ is exceeded when the $FED_{Thermal}$ is greater than 0.3

$FED_{Thermal}$ is a function of both radiant heat and convective heat.

Radiant Heat

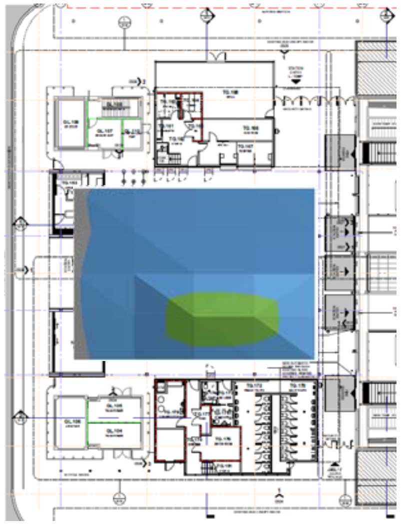
0.00-0.50 0.50-1.00 1.00-1.50 1.50-2.00 2.00-2.50 2.50-3.00

kW/m²

At 2.0m above floor level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds).except within the retail unit. Note 0.42 kW/m² is the background radiant heat flux within the model.

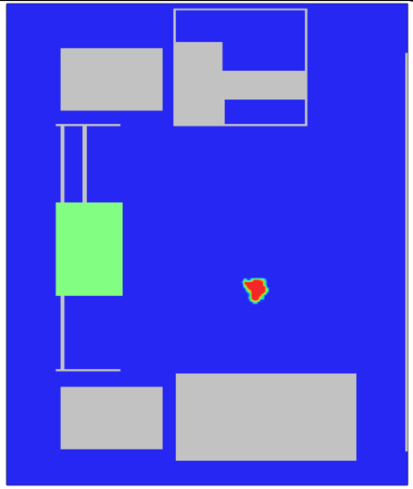
Therefore radiant heat can be discounted in the in $FED_{Thermal}$ calculation.

This also demonstrates the Performance Requirements of C3.8 are achieved as the radiation flux above the required 1.5 m above the floor (2.0 m) does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.



Temporary Entrance: Fire Scenario 2 – Fuel Controlled Fire

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv}) * \Delta t$

$FED_{Thermal} = (1/[4.1x10^{8} x\ 50^{-3.61}])*20$

$= 0.064$ (≤ 0.3 acceptable)

Required Safe Egress Time

The Required Safe Egress Time (RSET) can be expressed in the following equation:

RSET = $(t_d + t_n + t_{pre}) + (t_{trav}$ or $t_{flow})$

Each of these components are individually discussed and assessed below.

Alarm Time ($t_d + t_n$)

For the assessment, the alarm time has been based on visual detection due to the highly controlled nature of the space. Whenever the building is occupied there will be station staff and security staff manning the area. In addition, there is CCTV coverage which is monitored by the MC. The base case alarm time is considered to be via manual activation. This is conservatively estimated to be:

Alarm Time – 60 seconds

By 60 seconds the smoke plume is pronounced and extending along the ceiling. Therefore, the fire would be clearly visible to occupants as the majority of the Temporary Entrance is open plan, as shown below in Figure 7Figure 6 and Figure 8Figure 7.

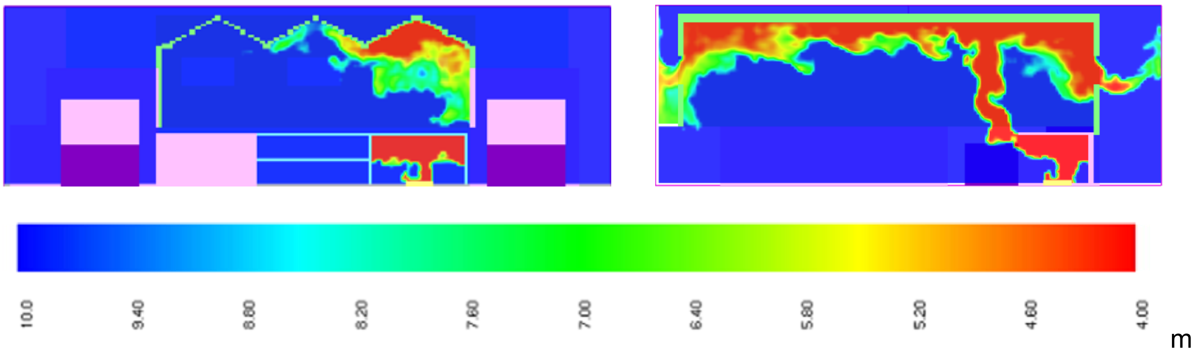


Figure 7: Fire Scenario 1: Cross Section of the Temporary Entrance, visibility (m) at 60 seconds

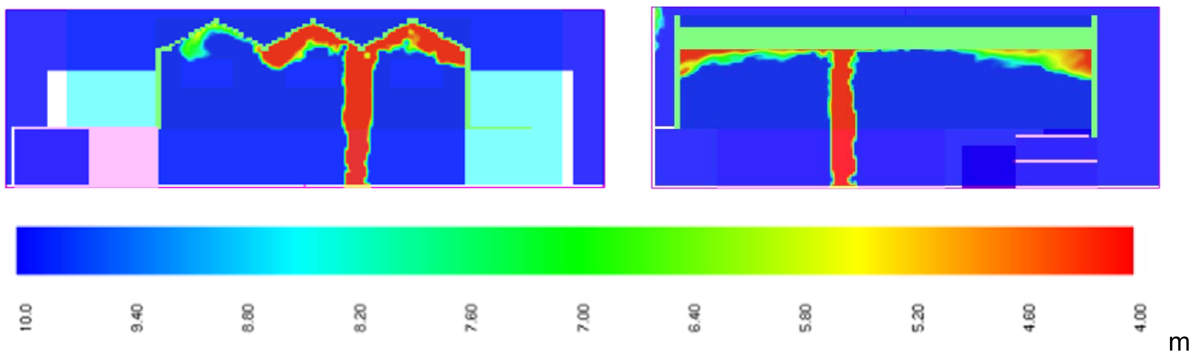


Figure 8: Fire Scenario 2: Cross Section of the Temporary Entrance, visibility (m) at 60 seconds

Pre-movement Time

As recommended in PD7974: Part 6, in a building where occupants are considered awake, alert and unfamiliar with the building, the pre-movement time in the enclosure of fire origin is 30 seconds.

The Circulation Area is a single enclosure, therefore:

Pre-movement Time – Up to 30s

Staff/ Occupants within the temporary blocks are remote from the fire, therefore:

Pre-movement Time – Up to 60s

Travel Time (t_{trav} or t_{flow})

There are multiple exits directly to outside sized to serve the Britomart Transport Centre, therefore, queuing at the exits is likely to be minimal. Occupants from other parts of the station are not required to egress through the Temporary Entrance in the event of a fire within the Temporary Entrance. The evacuation mode and staff will direct occupants to Britomart East. As such, the occupant load considers occupants within the Temporary Entrance, and not those at platform or other areas throughout the station. As the Staff areas within the temporary blocks are required to egress through the main circulation area, the Required Egress Time will also take into account staff evacuation from these BOH areas.

Table 63: Summary of populations, exits and aggregate exit width. Refer Table 2Table 2

Level	Estimated Maximum Population	Exits	Aggregate width	Travel Distance
Circulation Space	**Circulation space:** 590* Based on 1 m²/person and area 590 m² reduced to discount circulation space around exits **Temporary Blocks:** North: 0 All intermittently occupied. Population accounted for elsewhere spaces South: 6 Retail occupants not included as egress from the retail unit is directly to outside (i.e. not through the Temporary Entrance forecourt)	East (K Temp) 6.6 m North (J-Temp) 2.9 m South (L-Temp) 6.7 m	16.2 m*	32.6 m

* Assumption does not consider occupants within the retail units which have direct access to outside; aggregate egress width does not include exits through the retail units

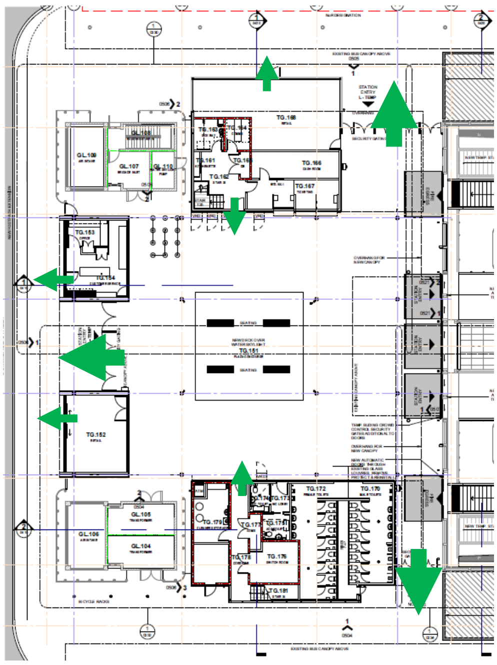


Figure 9: Egress from Temporary Entrance.

Travel Speed: S = k – akD

k 1.4 horizontal travel

a 0.266

D person \m² occupant density of the space
worst case 1 person/m²

S = 1.03 m/s horizontal (if < 1.2m/s) = 1.03 m/s FOH

S = 1.36 m/s horizontal (if < 1.2m/s) = 1.2 m/s Temporary Blocks

Travel Time: $T_{trav} = L_{trav}/S$

FOH T_{trav} = 20 m/ 1.03 m/s = 20 seconds

Temporary Blocks T_{trav} = [12.6 m/ 1.2 m/s = 11 seconds] + [20 m/ 1.03 m/s = 20 seconds] = 31

Flow Rate: $F_c = (1-aD)kDW_e$

D occupant density near flow constriction (i.e., for doors, use 1.9 persons/m²)

W_e effective width of component being traversed in metres (Aggregate width - Boundary layer 10 doors @ 0.3m per door)

F_c = (1-0.266*1.9)1.4*1.9*(16.2-3)

F_c = 17.36 persons/sec

Flow Time: T_{flow} = Persons/F_c = (590+6)/17.36

T_{flow} = 35 seconds

RSET

Time [s]	$t_d + t_n$	t_{pre}	t_{trav}	t_{flow}	**RSET**	**1.5 x RSET**
FOH	60	30	~~20~~	35	*125*	
Temporary Blocks	60	60	~~31~~	35	*155*	
Base case					***155***	***233***

ASET vs RSET Summary

Fire Scenario	Egress Scenario	ASET	RSET	ASET ≥ RSET
Retail Fire	Base case	> 1,200	233	Yes
Fuel Controlled Fire	Base case	> 1,200	233	Yes

Note: Sensitivity on the egress scenarios was not conducted as the Temporary Entrance remained tenable for the duration of the model. As results reached steady-state to 1,200 seconds the model would show tenable conditions indefinitely making additional egress scenarios redundant.

Louvre Selection

Variation between the louvres selected during the developed design process and the conditions modelled have been verified utilising NFPA 204[1] in lieu of re-modelling the Temporary Entrance.

As a minimum requirement, where the layer height exceeds 2.0 m it is considered that the natural ventilation provided is sufficient.

The FDS model demonstrated the smoke layer height was significantly greater than 2.0 m (approximately 7.4 m above ground level), providing indefinite evacuation time to occupants.

These results by the FDS model for the fuel controlled fire corroborate the NFPA204 calculation, as shown below.

- The FDS model was based on a Colt 3UL Louvre with dimensions 5.85 m wide by 2.875 m high, which has a discharge coefficient of 0.22
- The louvre selected was a Colt 2UL Louvre with dimensions 3.75 m wide by 3.715 m high, which has a discharge coefficient of 0.25.

Louvre Modelled in FDS

NFPA 204 Calculation for Natural Venting of Temporary Entrance			
Fire Parameters			
Heat Release Rate:	3500	kW	
HRRPUA:	550	kW/m2	
Heat Loss Coefficient, K:	0.5		
Layer Height:	7.04	m	vary to balance
Outlet Dimensions	(ignoring roof gaps)		
z(top)	9.50	m	
z(bottom)	6.63	m	
w	5.85	m	
n	6.00	m	
z(b,effective)	7.04	m	
H(c)	8.27	m	
A(t)	86.34	m2	
C(d)	0.22		
Inlet Dimensions	(ignore lower portion of louvers if z(s)>z(b))		
H1	3.50	m	
W1	8.00	m	
A1	28.00	m2	
H2	3.90	m	
W2	5.09	m	
A2	19.85	m2	
H3	3.81	m	
W3	8.25	m	
A3	31.43	m2	
A(t)	79.28	m2	
C(d,t)	0.88		
Calculations			
Fire Area:	6.36	m2	
Fire Diameter:	2.85	m2	
Limiting Flame Height:	3.24	m	
Virtual Origin:	-0.73	m	
Modifier	1.38		
Plume Mass Flow:	33.89	kg/s	
Smoke Temperature:	329.09	K	
Vent Mass Flow:	33.89	kg/s	
Variation:	0.00		

Selected Louvre

NFPA 204 Calculation for Natural Venting of Temporary Entrance			
Fire Parameters			
Heat Release Rate:	3500	kW	
HRRPUA:	550	kW/m2	
Heat Loss Coefficient, K:	0.5		
Layer Height:	6.28	m	vary to balance
Outlet Dimensions	(ignoring roof gaps)		
z(top)	8.95	m	
z(bottom)	5.20	m	
w	3.75	m	
n	6.00	m	
z(b,effective)	6.28	m	
H(c)	7.62	m	
A(t)	60.02	m2	
C(d)	0.25		
Inlet Dimensions	(ignore lower portion of louvers if z(s)>z(b))		
H1	3.20	m	
W1	7.10	m	
A1	22.72	m2	
H2	3.20	m	
W2	2.95	m	
A2	9.44	m2	
H3	3.20	m	
W3	7.84	m	
A3	25.09	m2	
A(t)	57.25	m2	
C(d,t)	0.88		
Calculations			
Fire Area:	6.36	m2	
Fire Diameter:	2.85	m2	
Limiting Flame Height:	3.24	m	
Virtual Origin:	-0.73	m	
Modifier	1.49		
Plume Mass Flow:	29.30	kg/s	
Smoke Temperature:	334.71	K	
Vent Mass Flow:	29.30	kg/s	
Variation:	0.00		

[1] NFPA 204 – 2015, Standard for Smoke and Heat Venting

The results of the NFPA 204 calculation, based on the fire parameters modelled in FDS, showed that there is good agreement for the modelled louvres, with the hand calculation being slightly more conservative.

The calculation also showed the selected louvre provides sufficient natural ventilation such that the smoke layer did not descend to the bottom of the louvres, maintaining a layer height significantly greater than 2.0 m above ground level. The natural ventilation provisions including the selected louvre are therefore appropriate for use within the Temporary Entrance.

System Failures

This assessment of system failures has considered the following system failure scenarios.

System	Description	Assessment	Comment
Smoke Management	Reliance on any mechanical or electrical component for activation	Qualitative	The space is permanently naturally ventilated; there is no reliance on mechanical or electrical components for activation
Fire Closures	Fire and/or smoke control doors or similar fire closures. Where installed and maintained in accordance with NZ or international standard the system is considered sufficiently reliable.	Qualitative	The Temporary Entrance including the Temporary Blocks is a single firecell which is fire sprinkler protected throughout. Electrical/ Comms rooms that are fire separated from surrounding areas have fire/smoke control doors. Given the function of these rooms the doors will be closed except when accessed to undertake works/inspections.
Fire sprinkler system	Fire sprinkler systems system failure is considered highly unlikely as supported by many assumptions in the NZBC C/AS documentation which permit numerous concessions where fire sprinkler systems are installed. FEDG notes that, in New Zealand, fire sprinkler systems have a very good reliability record.	N/A	The system will be installed and maintained in accordance to NZ Standards
Fire detection & alarm system	Automatic fire alarms installed to a recognised national or international Standard, can be considered to be sufficiently reliable. This is supported by many assumptions in the NZBC C/AS documentation including the allowance to increase the length of	Qualitative	Installed in accordance to NZ Standards; only in areas where there is no sprinkler protection. In the event fire detection fails the area will either be contained to the area or fire origin or eventually activate the fire sprinkler system. Further redundancy is provided by: The alternative means by which fire can be detected is as follows:

System	Description	Assessment	Comment
	escape routes where fire and detection systems are installed.		• Visual detection by building occupants. • Visual detection by staff monitoring the CCTV • Automatic heat detection using the sprinklers as thermal detectors. The alternative means by which a fire alarm may be raised and evacuation initiated is as follows: • Staff / occupants. • Staff manually initiating the occupant warning system or making announcements over the PA system.
Exit Blocked	An escape route may be blocked due to proximity of the fire source	Qualitative	Multiple exits provided. Tenable conditions provided for greater than 1.5 x RSET allows additional time for occupant egress in the event an exit is blocked. Furthermore, the area is sprinkler protected reducing the probability an exit will be blocked by a fire event. This is supported by many assumptions in the NZBC C/AS documentation including the concessions with respect to the provision for unusable escape routes.

Fire Fighting Operations

The Temporary Entrance itself is less than 5,000m² and is fire sprinkler protected. In isolation, it is not required to meet the Performance Requirement C3.8. However, it has been demonstrated that the radiant heat flux 2.0 m above floor level (more onerous than 1.5 m) is well under the 4.5 kW/m² limit required of Performance Requirement C3.8.

Conclusions

The Temporary Entrance meets the Performance Requirements C3.8, C3.9, C4.3, C4.4, C4.5, C5.8, and C6.2 of the NZBC.

Appendix D
Enabling WorksTemporary Works Britomart Station Assessment Temporary Works Britomart Station Assessment

Analysis

This section presents a quantitative timeline assessment of the Available Safe Egress Time (ASET) compared with the Required Safe Egress Time (RSET) for occupants within Britomart Station, also referred to as Britomart Transport Centre (BTC).

Britomart Station is assessed by alternative solution, and the results will be compared with the results from Stacey Agnew who undertook the most recent modelling for the existing consent.

Britomart Station has been assessed in the Temporary Works State and the Permanent Works State. This section presents the results during the Temporary Works, the Permanent Works section uses many of the same inputs; however, the geometry is different.

Available Safe Egress Time

The ASET times have been calculated by undertaking CFD modelling of the interconnected parts of the building. The inputs for various parts of these models are summarised below.

Design Fire and Fire Scenarios

The fire scenarios and design fires have been agreed within the design team and stakeholders as part of the FEB process.

Train fires have been considered the worst-case scenarios. As discussed in the FEB, DMU and diesel trains will not be operating within Britomart Station by the time the Temporary Works commence. The EMU fire scenarios are set out in a separate document, identifying Design Fire and Sensitivity Cases for CRL. The parameters of these scenarios are summarised below.

Table 1: Design Fire Parameters

Design Fire Parameters	Design Fire 1	Design Fire 2
Design Fire ID	Fast t^2 4MW	Medium t^2 10MW
Fire growth rate	Fast t^2 fire	Medium t^2 fire
HRR	Starts at 1.055 MW Peak 4 MW As calculated below	Starts at 0.380 MW Peak 10 MW As calculated below
Area	8 m x 2 m	20 m x 2 m
Comment	Train doors open Windows remain intact for duration of model	Train doors open Windows remain intact for duration of model

In a worst-case scenario, it is assumed that a train fire starts prior to the train entering the tunnel portal into Britomart Station, but is not detected until after the train has entered the portal. The size of the fire once the train enters the station is bounded by the following assumptions due to operating procedures:

- if a fire is detected on the train prior to reaching the portal it will not proceed into the tunnels,
- if a fire is detected on the train within the Britomart tunnels, it will proceed into the station.

The following train timeline events describe the Britomart Station Design Fires. These assumptions have been previously presented to, and agreed to by the project stakeholders.

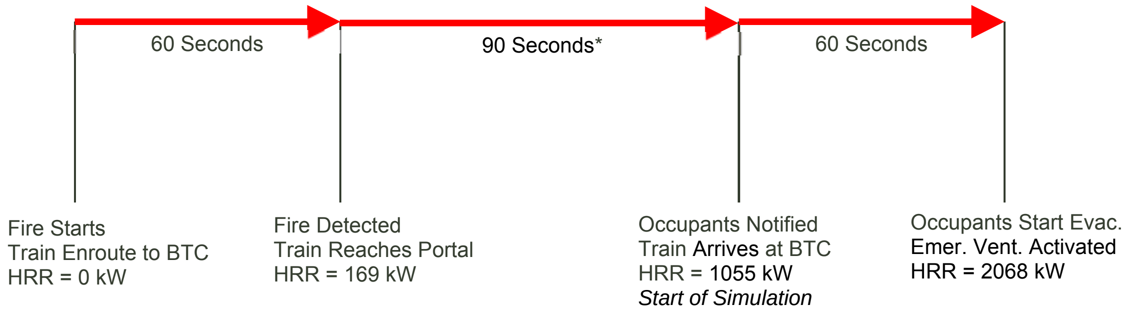


Figure 1: Timeline of Events Fast t² Train Fire

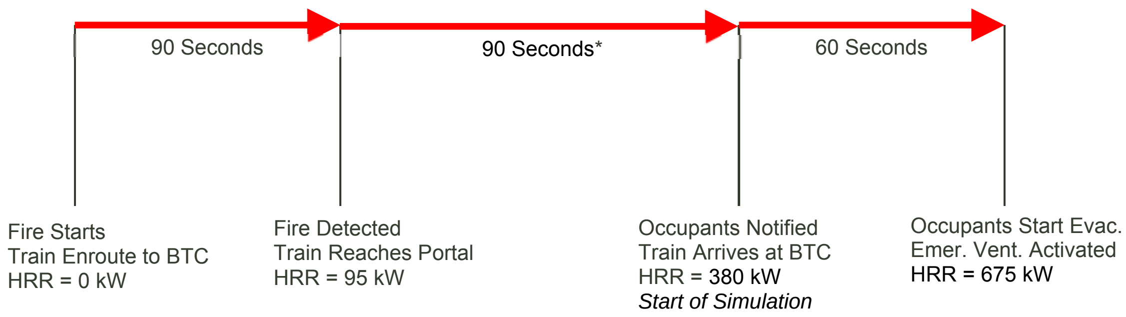


Figure 2: Timeline of Events Medium t² Train Fire

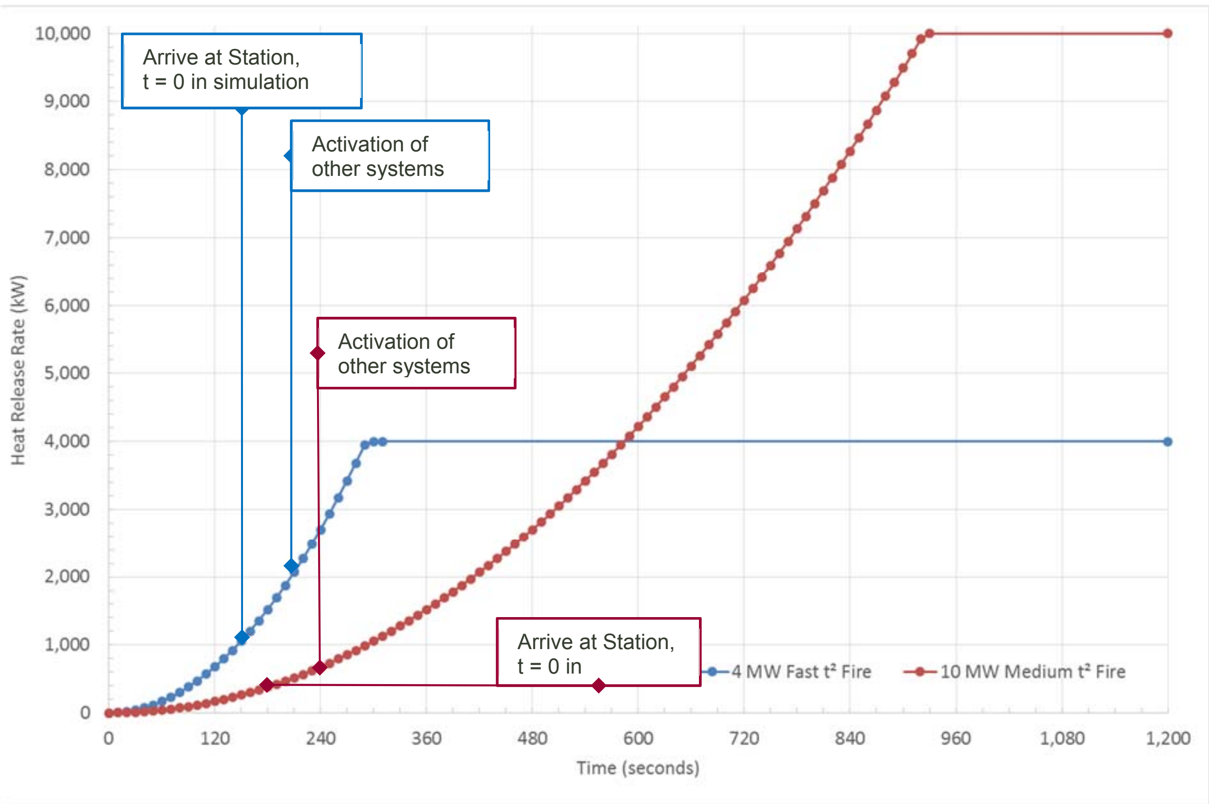


Figure 3: Britomart Station Train Design Fires

The following locations were investigated for the different fire scenarios:

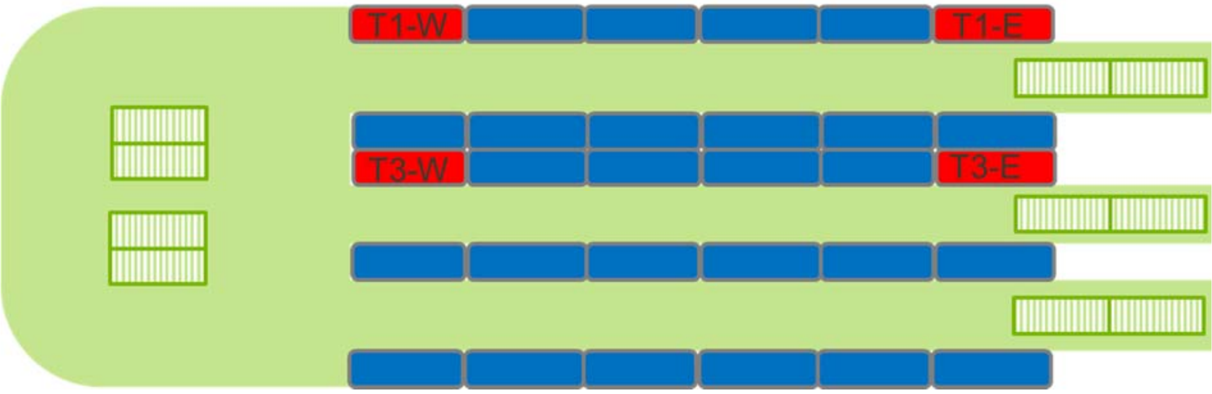


Figure 4: Britomart Station Fire Scenario Locations

Track 1: Examine smoke spread under plenum structure

Track 3: Examine smoke development/spread in high bay space

West end: Maximum potential threat to primary egress paths to west; stresses egress systems to east

East end: Stresses egress systems to west

Table 2: Fire Scenarios

Fire Scenario	Location	Design Fire	Case	Comments
1E: T1-W	Track 1 Carriage 1	Fast t^2 4 MW	Base Case	Fully functioning systems
2E: T3-W	Track 3, Carriage 1	Fast t^2 4 MW	Base Case	Fully functioning systems
3E: T1-E	Track 1, Carriage 6	Fast t^2 4 MW	Base Case	Fully functioning systems
4E: T3-E	Track 3, Carriage 6	Fast t^2 4 MW	Base Case	Fully functioning systems
5E: T1-W	Track 1, Carriage 1	Medium t^2 10 MW	Sensitivity	Fully functioning systems
6E: T1-W	Track 1, Carriage 1	Fast t^2 4 MW	Redundancy	50 % Mechanical exhaust
7E: T1-W	Track 1, Carriage 1	Fast t^2 4 MW	Redundancy	Smoke curtain failure

Results from Fire Scenario 1 to 4 showed the highest challenge fire location was Fire Scenario 1; as such, the sensitivity and redundancy cases were tested at the Track 1, Carriage 1 location.

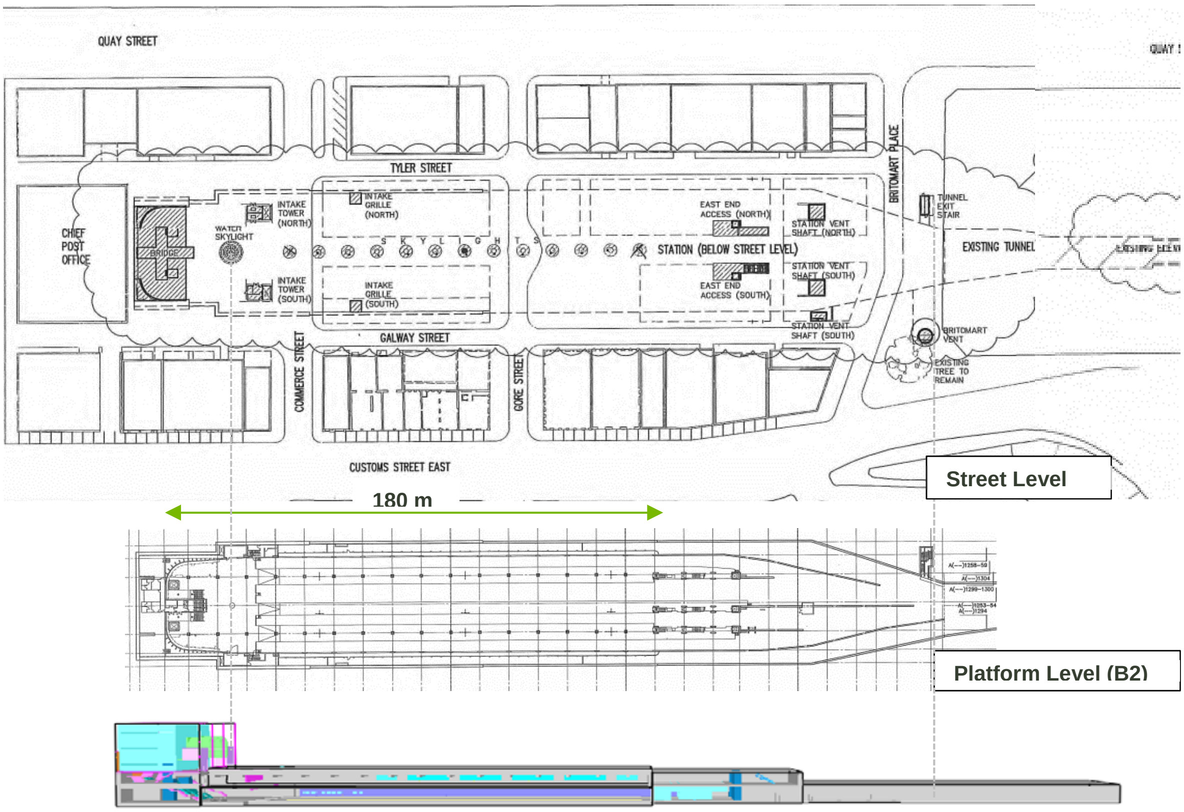


Figure 5: Britomart Station Overview – Plans and FDS model geometry

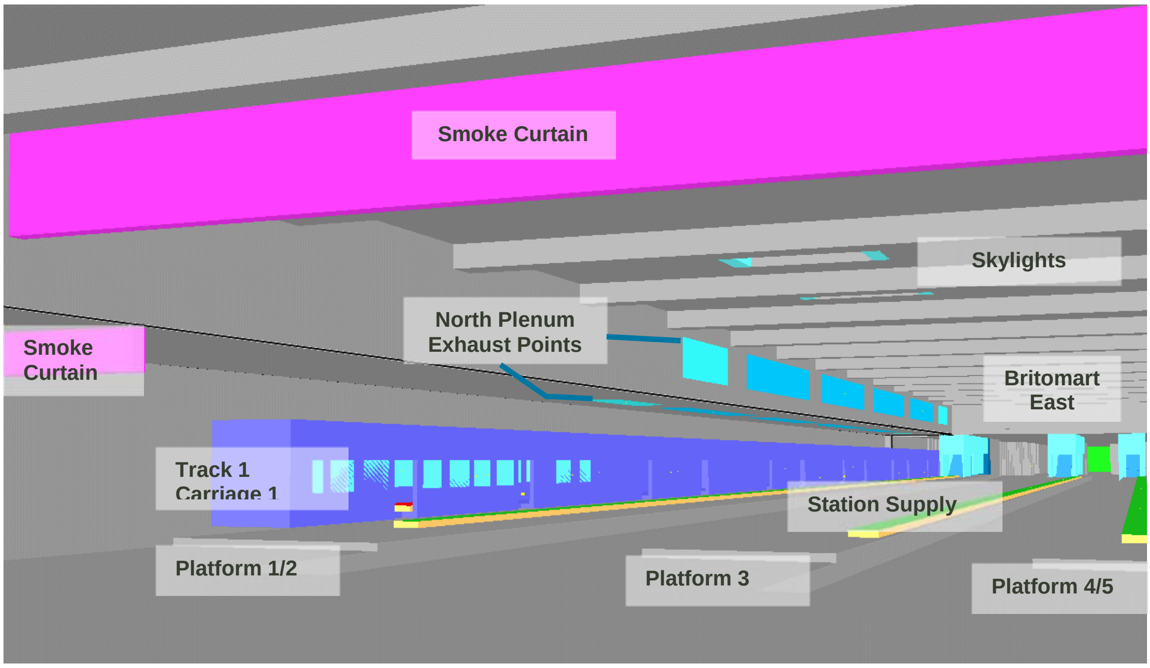


Figure 6: Britomart Station Platform – Internal View

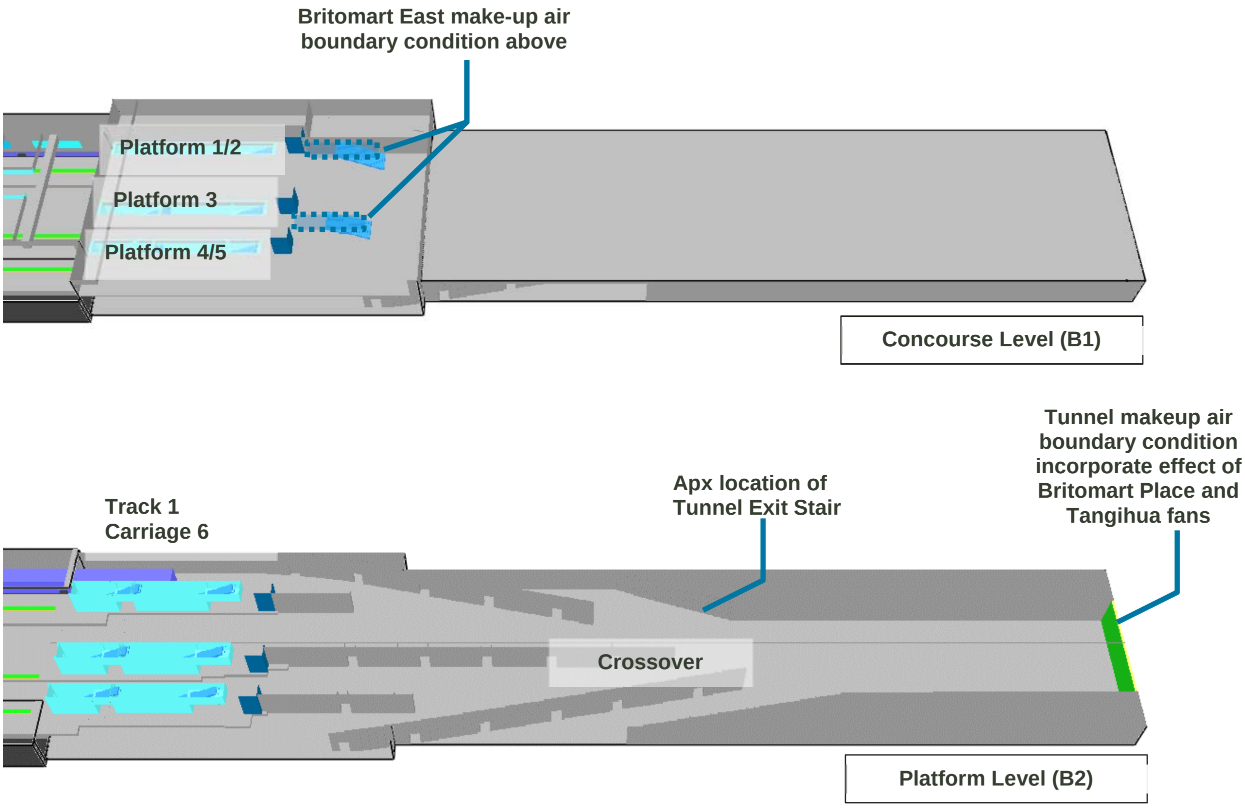


Figure 7: Britomart East and Tunnel Crossover

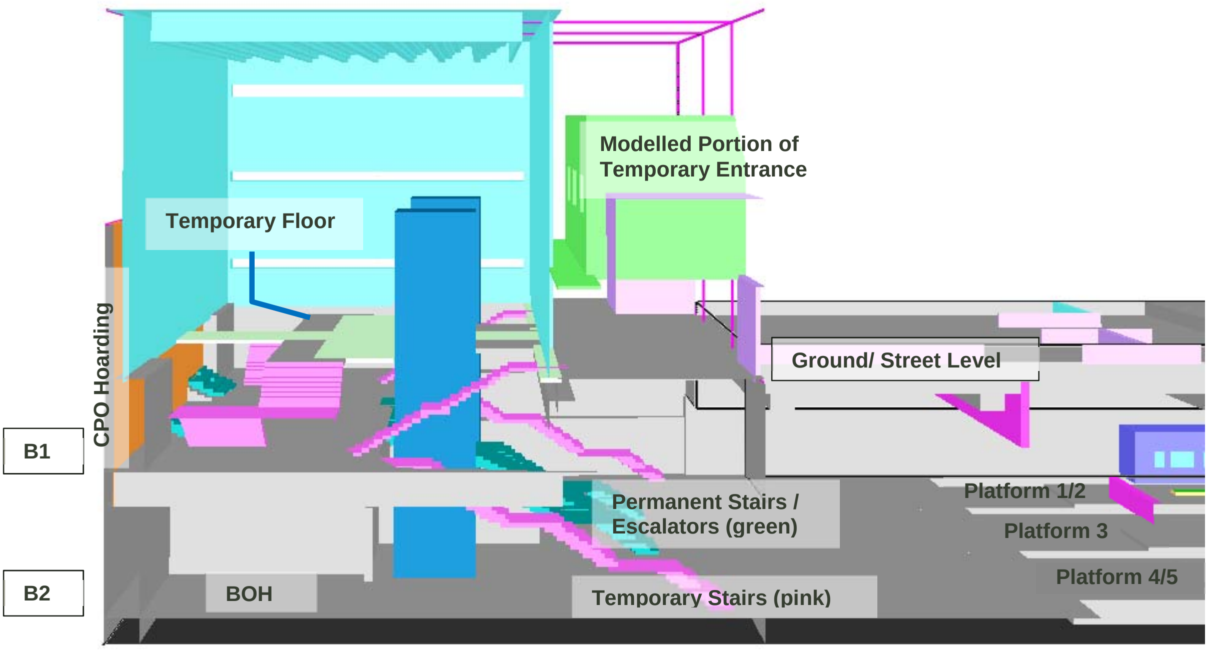


Figure 8: Britomart West – Temporary Works

Note: Temporary Accommodations at Level B2 between the platforms and the glasshouse not modelled. These are fire separated from the surrounding space and sprinkler protected.

FDS Parameters

The following outlines the FDS parameters used for the Britomart Station models. It is noted that where possible, the same assumption used by Stacey Agnew in the existing consent documents has been used in the current assessment. This is to maintain modelling conditions as consistent as possible to provide a reasonable comparative assessment

Inputs		Comments
Model geometry	As per drawings	
Grid resolution (4 < D*/δx < 16)	0.10 ~ 0.40 0.15 ~ 0.60	Based on Q = 4.0 MW Based on Q = 10.0 MW
Mesh size	0.2 m x 0.2 m x 0.2 m 0.4 m x 0.2 m x 0.2 m	Britomart Station and Glasshouse Crossover and Tunnel
Simulation time	Begins: - 60 seconds Ends approximately: 1200 seconds	From -60 seconds to 0 seconds the model is run with the initial ventilation conditions to allow the system to start in equilibrium. Model is run until at least • 1.5 x RSET for base cases and • RSET for sensitivity & redundancy cases
Fuel type*	Polyurethane, $C_{6.3}H_{7.1}P_{2.1}N_1$	Consistent with Stacey Agnew Report.
Soot yield	0.051 kg_{soot} / kg_{fuel}	Yields based on average of major internal lining materials used in Sydney Generation 2 EMU rolling stock (from previous Arup studies). These values are considered conservative for materials used in AM Class EMUs which are constructed to BS6853 category 1b and are therefore to a higher level of material fire performance (with stricter controls on material heat release rate and smoke emission opacity)
CO yield rate	0.026 g/g	
Visibility Factor	2.0	Appropriate for reflective surfaces (e.g., walls)
Heat release rate per unit area (HRRPUA)	HRRPUA = 250 kW/m^2	Based on the fire size within the carriage; the fire is horizontally located and distributed throughout the floor
Smoke Curtains (West)	Existing 2 m deep smoke curtains beneath the roof: at Grid X211 000. Existing 1 m smoke curtains beneath the north and south exhaust plenum: at Grid X211 000. Deployment time: 30 s after system activation. Redundancy case: Smoke curtains fail to deploy.	Consistent with Stacey Agnew Report. Note: deployment time measured by Stacey Agnew as 21 s.

Inputs		Comments
Smoke Baffles (Platform East)	Glass downstands in front of the entrance to escalators and stairs, with the bottom of glass downstand to be 2.5m above floor, with full height separation on both sides of the escalators and stairs.	Consistent with Stacey Agnew Report.
Supply via Britomart East	Defined boundary condition based on 1D model.	See below for calculations and justification
Open louvres in the Glasshouse	Louvre openings shall be reduced to a minimum of 50% of that available during pre-Temporary Works conditions. To simplify the louvres in the FDS model inputs: Equivalent model open area: 37.5 m^2 on each elevation 3 off 18.8 m long x 0.6 m high	Consistent with Stacey Agnew Report. Closure or modification of louvres allowed for during Temporary Works: minimum 50% of the pre-enabling louvre area (Stacey Agnew conditions) to be maintained throughout the Temporary Works. In FDS, the Glasshouse is the only free boundary, other boundary flow rates are defined by 1D network modelling. East & west elevation louvres assumed closed. Louvres on both north and south elevations are evenly distributed. See below for calculations and justification
Doors in the Glasshouse	N/A	In the event of an emergency occupants will evacuate through these doors, so they are likely to be open. It has been assumed that they are closed to ascertain potential maximum airflows through the louvres.
Temporary Accommodation	N/A	In the Britomart Station models the Temporary Accommodation is not included in the simulation domain; with the east side louvres closed and the Glasshouse doors assumed closed such that there is no interaction between the spaces
Smoke Exhaust	At t = 0 s: running at 30 % (105 m^3/s) 60s ramp-up time to 100 % (350 m^3/s) after activation Flow rates defined based on 1D model. Redundancy case: 50% Exhaust capacity in Britomart Station	See below for calculations and justification Note: Stacey Agnew measured ramp up time from 30% to 100% of 10 s. Redundancy case based on SCADA node failure.
Supply Air	At t = 0 s: running at 30 % (55 m^3/s)	Input into 1D model. See below for calculations and justification

Inputs		Comments
	60 s ramp-down time to 0 % ($0\ m^3/s$) after activation	
Tunnel	Defined flow boundary condition based on 1D model.	In Fire Mode, Britomart Place and Tangihua vents in exhaust mode. Each exhaust $180\ m^3/s$ See below for calculations and justification
Boundary Conditions	Station Structure 'CONCRETE' (thermally thick) Glass elements 'GLASS' Train carriage 'ADIABATIC' Temp stairs 'Steel' 6mm thick Temporary Entry – Plexiglass (acrylic glass)	Updated from C1 FEB In general consistent with Stacey Agnew Report Train Carriage: system-wide assessment used 'steel'. Stacey Agnew Report used a composite. References: Concrete – J.P, 1986. Heat Transfer, Sixth. ed. McGraw-Hill Glass – ASHRAE Fundamentals Handbook, 1997 Steel – Buchanan, A., Structural Design for Fire Safety, Plexiglass – Bejan, A, Heat Transfer
Ambient Temperature	20°C	
Wind Conditions	Not modelled	Prevailing wind condition: NW at approximately 10 knots.
Heat Flux Perpendicular to Train Door	In front of train door, from the edge of the platform on Platform 1: • 3 m • 6 m	To determine if occupants can egress past the carriage of fire origin. On Platform 1, 6 m is the far edge of platform On Platform 3, 6 m from the edge of the platform will be located on Track 4.
Heat Flux Devices	18 off, 1.5 m above platform level 20.0 m spacing	Located centrally along each platform Located at 1.5m above floor level to permit assessment in accordance with NZBC C3.8 "the maximum radiation flux at1.5 m above the floor is no greater than4.5 kW/m^2…"
Other Outputs	Slice files presented: • 2m above platform floor, concourse floor, glasshouse floor. • Through the centre of the station (apx middle of Platform 3)	Plot 3D - 30 seconds Slice – 6 seconds Devices – 1 second HRR – 1 second

Ventilation Conditions

The capacities and response mode modelled was proposed and agreed for use with stakeholders in the stakeholder meetings held 11 August 2015.

Note: during detailed design it was proposed that the existing response modes be maintained throughout the Temporary Works. Validation of the existing ventilation response modes are addressed in the Existing Ventilation Strategy Section of this Appendix.

Calibration

The 1D flow modelling is consistent with the Stacey Agnew approach and was calibrated utilising the same flow measurements in 2006 and their 2011 analysis.

			Station Exhaust		Britomart Place		Tangihua			
			-407 m³/s		-221 m³/s		0 m³/s			
HH louvres	221.3	m³/s								
				<		<		<		
CPO Tunnel	22.9	m³/s		-89.2 m³/s		-192.8 m³/s		-192.8 m³/s		Portal
			n1	s1	n2	s2	n3	s3	n4	
Britomart East	73.6	m³/s	-18.0 Pa		-17.5 Pa		-10.07 Pa		0.00 Pa	
					117.4					
					Light Rail Vents					

Scenario Settings

Jet Fans	Active	Direction	
West	0	E	1
East	0	E	1
Station Mechanical			
Exhaust	100%		
Supply	0%		
Britomart Place			
Exhaust	100%		
Tangihua			
Exhaust	0%		
Vents/Openings			
Head House Louvres	Open	1	
CPO Tunnel	Open	1	
Britomart East Stairs	Open	1	
Light Rail Vents	Open	1	
Adverse Portal Wind			
Speed	0	m/s	

Physical Parameters

Jet Fans		
Nominal Thrust	990	N
Diameter	1.12	m
Discharge Area	0.99	m²
Exit Velocity	28.94	m/s
Install Location	1-Soffit	
Install Efficiency	0.85	
Tunnel Area (West)	58.25	m²
Tunnel Area (East)	58.75	m²
Station Mechanical		
100% Exhaust	407	m³/s
100% Supply	210	m³/s
Britomart Place		
100% Exhaust	221	m³/s
Tangihua		
100% Exhaust	158	m³/s

Ambient Parameters

Temperature	293	K
Air Density	1.2	kg/m3
Pressure (Gauge)	0	Pa

Resistances

Vents/Openings		
Headhouse Louvers	0.00037	
CPO Tunnel	0.03432	
Britomart East	0.00332	
Light Rail Vents	0.00127	
Tunnels	Forwards	Backwards
Station-to-Britomart	0.00006	0.00006
Britomart-to-Tangihua	0.00025	0.00020
Tangihua-to-Portal	0.00059	0.00027

Pressures

Station	-18.00	Pa
Britomart Place	-17.51	Pa
Tangihua	-10.07	Pa
Portal	0.00	Pa

Press to Solve for Station Pressure

Flows

Station Exhaust	-407.0	m³/s	
Station Supply	0.0	m³/s	
Head House Louvres	221.3	m³/s	
CPO Tunnel	22.9	m³/s	
Britomart East Stairs	73.6	m³/s	
Light Rail Vents	117.4	m³/s	
Britomart Place	-221.0	m³/s	
Tangihua	0.0	m³/s	
Station-to-Britomart	-89.2	m³/s	To West
Britomart-to-Tangihua	-192.8	m³/s	To West
Tangihua-to-Portal	-192.8	m³/s	To West

Tunnel Friction Losses

Station-to-Britomart	0.49	Pa
Britomart-to-Tangihua	7.43	Pa
Tangihua-to-Portal	10.07	Pa

Jet Fan Pressures

Tunnel Air Velocity		
Britomart-to-Tangihua	-3.31	m/s
Tangihua-to-Portal	-3.28	m/s
Thrust		
Britomart-to-Tangihua	0.00	N
Tangihua-to-Portal	0.00	N
Pressure		
Britomart-to-Tangihua	0.00	Pa
Tangihua-to-Portal	0.00	Pa

Pressure Sum Check

Station	n1	-18.00	Pa
	n1 to n2	0.49	Pa
Britomart Place	n2	-17.51	Pa
	n2 to n3	7.43	Pa
Tangihua	n3	-10.07	Pa
	n3 to n4	10.07	Pa
Portal	n4	0.00	Pa
	Wind	0.00	Pa
	SUM	**0.00**	**Pa**

Base Case Flows

The proposed mode of operation during a station platform emergency is to operate the station exhaust at 100% capacity, shut the supply air off, and draw all make-up through the glasshouse and east entrances. Fans at Britomart Place and Tangihua are operated in exhaust (100%) in order to limit the portion of make-up air drawn via the eastern end of the station and achieve requisite airflows at the west end of the station. This is a modification of the pre-enabling works mode as shown below.

Table 3: SCADA Response Modes Pre Enabling Works (Pre EW) and during the Temporary Works (TW)

Stage	Ventilation Strategy	Station Supply Fans	Station Transfer Fans	Station Exhaust Fans	Britomart Place	West Tunnel Jet Fans	Tangihua Street Exhaust Fans	East Tunnel Jet Fans
Pre EW Calibration	Fire at Station Platforms	Off	Off	Exhaust*	Exhaust	4 fans to east	Off	Off
Pre EW[1]	Fire at Station Platforms	Off	Off	Exhaust*	Exhaust	2 fans to east	Off	Off
TW	Fire at Station Platforms	Off	Off	Exhaust 350 m^3/s	Exhaust 180 m^3/s	Off	Exhaust 180 m^3/s	Off

* Supply and exhaust indicate that all fans are operating at 100% capacity.

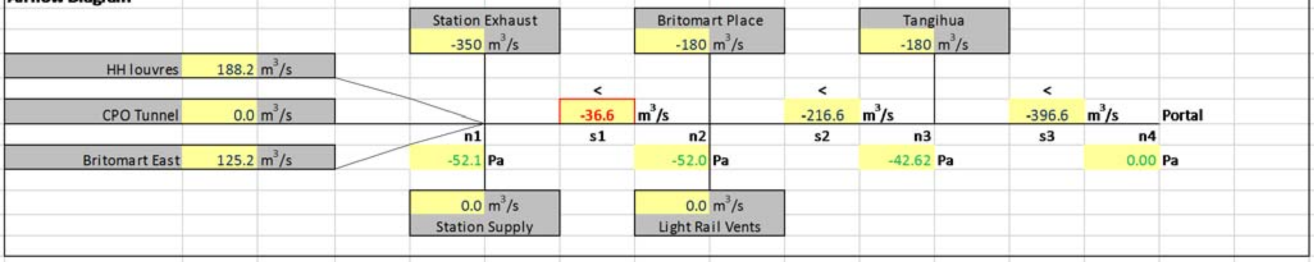
[1] Current consented ventilation strategy (Stacey Agnew FER rev 7 onwards), during detailed design it was proposed to maintain this strategy. Refer Existing Ventilation Section of this Appendix.

The capacities used for the modelling have been taken from the Support Phase – Britomart Station Review 228072-AC-RPT-085. The station exhaust capacity to be used is the nameplate capacity (350 m^3/s) of the fans, not the measured flow (407 m^3/s) determined during the 2006 assessment, as this provides a margin of safety over the design capacity.

Flows will be constrained at select model boundaries (Tunnels and Britomart East), to allow flow conditions, in the appropriate quantity, to be predicted at the glasshouse. The approach effectively captures the relative pressure drops at make-up air locations throughout the station.

The resulting makeup air split is 54 % West : 46 % East. The makeup air from the west is wholly through the Glasshouse louvres; the makeup air from the east is a combination of air paths through Britomart East and from the tunnel. The results of the 1D airflow calculation are illustrated below:

Airflow Diagram



Scenario Settings

Jet Fans	Active	Direction		
West	0	E		1
East	0	E		1
Station Mechanical				
Exhaust	100%			
Supply	0%			
Britomart Place				
Exhaust	100%			
Tangihua				
Exhaust	100%			
Vents/Openings				
Head House Louvres	Open		1	
CPO Tunnel	Closed		0	
Britomart East Stairs	Open		1	
Light Rail Vents	Closed		0	
Adverse Portal Wind				
Speed	0	m/s		

Pressures

Station	-52.09	Pa
Britomart Place	-52.00	Pa
Tangihua	-42.62	Pa
Portal	0.00	Pa

Press to Solve for Station Pressure

Flows

Station Exhaust	-350.0	m³/s	
Station Supply	0.0	m³/s	
Head House Louvres	188.2	m³/s	
CPO Tunnel	0.0	m³/s	
Britomart East Stairs	125.2	m³/s	
Light Rail Vents	0.0	m³/s	
Britomart Place	-180.0	m³/s	
Tangihua	-180.0	m³/s	
Station-to-Britomart	-36.6	m³/s	To West
Britomart-to-Tangihua	-216.6	m³/s	To West
Tangihua-to-Portal	-396.6	m³/s	To West

Legend

pull-down
input
calculation (do not modify)
calibrated items (do not modify)

Louver Definition/Scalar*

Fraction Open (X)	0.50
1/X	2.00
f=(1/X)^2	4.00

Physical Parameters

Jet Fans		
Nominal Thrust	990	N
Diameter	1.12	m
Discharge Area	0.99	m²
Exit Velocity	28.94	m/s
Install Location	1-Soffit	
Install Efficiency	0.85	
Tunnel Area (West)	58.25	m²
Tunnel Area (East)	58.75	m²
Station Mechanical		
100% Exhaust	350	m³/s
100% Supply	183.2	m³/s
Britomart Place		
100% Exhaust	180	m³/s
Tangihua		
100% Exhaust	180	m³/s

Tunnel Friction Losses

Station-to-Britomart	0.08	Pa
Britomart-to-Tangihua	9.38	Pa
Tangihua-to-Portal	42.62	Pa

Jet Fan Pressures

Tunnel Air Velocity		
Britomart-to-Tangihua	-3.72	m/s
Tangihua-to-Portal	-6.75	m/s
Thrust		
Britomart-to-Tangihua	0.00	N
Tangihua-to-Portal	0.00	N
Pressure		
Britomart-to-Tangihua	0.00	Pa
Tangihua-to-Portal	0.00	Pa

Ambient Parameters

Temperature	293	K
Air Density	1.2	kg/m3
Pressure (Gauge)	0	Pa

Pressure Sum Check

Station	n1	-52.09	Pa
	n1 to n2	0.08	Pa
Britomart Place	n2	-52.00	Pa
	n2 to n3	9.38	Pa
Tangihua	n3	-42.62	Pa
	n3 to n4	42.62	Pa
Portal	n4	0.00	Pa
	Wind	0.00	Pa
	SUM	**0.00**	Pa

K-Factors

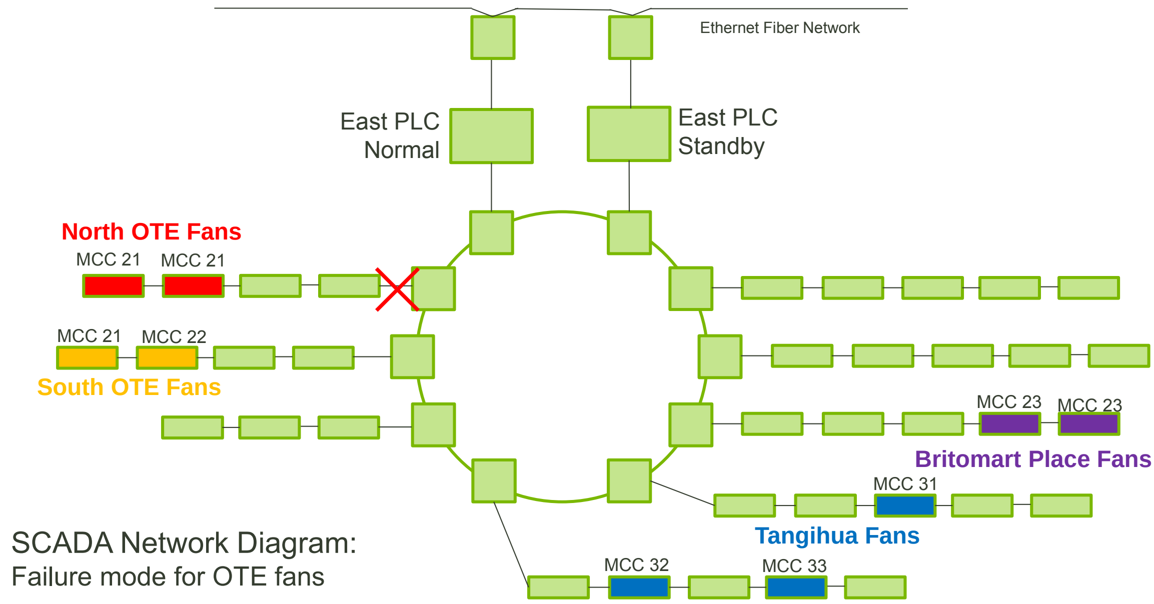
Vents/Openings			
Headhouse Louvres	0.00147	0.00037	base
CPO Tunnel	0.03432		
Britomart East	0.00332		
Light Rail Vents	0.00127		
Tunnels	Forwards	Backwards	
Station-to-Britomart	0.00006	0.00006	
Britomart-to-Tangihua	0.00025	0.00020	
Tangihua-to-Portal	0.00059	0.00027	

Redundancy Flows (50% mechanical ventilation)

Total failure of the smoke exhaust system is not a realistic failure scenario as there is no single point of failure for all mechanical systems, save for a region-wide power loss which would also result in power loss to the entire station which would likely necessitate closure of the station. The worst case would be the loss of a single SCADA node or Motor Control Centre (MCC). Potential ventilation failure modes have been determined by Mott Macdonald as follows:

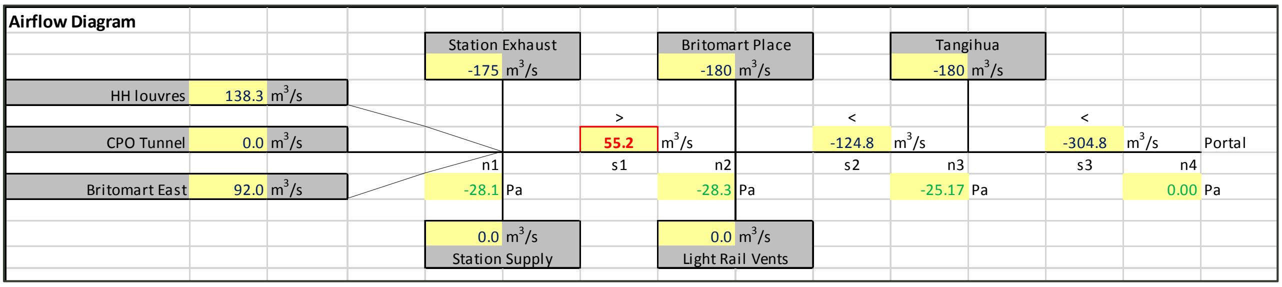
Failure	Britomart	Britomart Place	Tangihua
Fan/VSD	Loss of 1 of: ID201-2E1 (87.5m^3/s) ID202-2E2 (87.5m^3/s) ID203-2E3 (87.5m^3/s) ID204-2E4 (87.5m^3/s)	Loss of 1 of: ID205-19F2 (90m^3/s) ID206-19F1 (90m^3/s)	Loss of 1 of: ID301-20F1 (60m^3/s) ID302-20F2 (60m^3/s) ID303-20F3 (60m^3/s)
MCC	Loss of: MCC21 (ID201-2E1, ID202-2E2: 2 x 87.5m^3/s) MCC22 (ID203-2E3, ID204-2E4: 2 x 87.5m^3/s)	Loss of: MCC23 (ID205-19F2, ID206-19F1: 2 x 90m^3/s)	Loss of: MCC31 (ID301-20F1: 60m^3/s) MCC32 (ID302-20F2: 60m^3/s) MCC33 (ID303-20F3: 60m^3/s)
SCADA Link	Loss of: MCC21 (ID201-2E1, ID202-2E2: 2 x 87.5m^3/s) MCC22 (ID203-2E3, ID204-2E4: 2 x 87.5m^3/s)	Loss of: MCC23 (ID205-19F2, ID206-19F1: 2 x 90m^3/s)	Loss of: MCC31 (ID301-20F1: 60m^3/s) MCC32 + MCC33 (ID302-20F2, ID303-20F3: 2 x 60m^3/s)

The SCADA node failure conditions is illustrated below, where a single link can result in loss of both fans serving either the north or south station exhaust plenums.



SCADA Network Diagram:
Failure mode for OTE fans

The redundancy case (worst-case with respect to exhaust from Britomart Station) would be the loss of the SCADA link to one of the MCCs which result in losing half of the exhaust capacity of the Over Track Exhaust (OTE) within Britomart Station. The model considered failure of the north side exhaust. This is considered the 'worst-case' as it's the plenum over the design fire location.



The resulting makeup air split is 79 % West : 21 % East. The makeup air from the west is wholly through the Glasshouse louvres; the makeup air from the east is a combination of air paths through Britomart East and from the tunnel.

Results

Our assessment of the four base cases determined that the worst-case fire location was T1-W, as the fire plume is disrupted by the plenum above.

As such the sensitivity and redundancy cases were modelled at the worst base case location (T1-W).

Fire Scenario		Fire Location	Simulation Time	Britomart East ASET Time [s]	Britomart West ASET Time [s]	Comments
1E	Base Case	T1-W	1,200	> 1,200	> 1,200	
2E	Base Case	T3-W	1,200	> 1,200	> 1,200	
3E	Base Case	T1-E	1,110	> 1,110	> 1,110	Britomart East Platform 1/2 exit unavailable due to tenability criteria within the vicinity of the exit being exceeded
4E	Base Case	T3-E	1,200	> 1,200	> 1,200	Britomart East Platform 3 exit unavailable due to tenability criteria within the vicinity of the exit being exceeded
5E	Sensitivity - 10MW fire	T1-W	1,200	> 1,200	B2: 720 B1: > 1,200 GH: > 1,200	Visibility near the stairs on B2 starts to decrease at ~720 seconds; however, occupants can still travel up the stairs through clear air (tenable conditions).
6E	Redundancy - 50% Exhaust	T1-W	846	> 846	B2: 588 B1: 318 GH: 384	ASET for Britomart West was considered 318 seconds. Occupants within the Glasshouse after 318 seconds are still provided with tenable conditions on egress paths. Egress routes within this area are intuitive, it is expected that occupants in the egress path will continue to final exits despite low visibility. Visibility tenability criterion falls below 10 m; however, no other tenability criteria are exceeded. Occupants can still evacuate in lower visibility though travel speeds are expected to decrease. As noted in the reference design travel speed continues to decrease until visibility decreased below 3 m, which experiments have shown occupants are reluctant to move through. Occupants are provided with indefinite ASET at Britomart East.
7E	Redundancy - no smoke curtain	T1-W	660	> 660	> 660	

* The concourse at Britomart East is effectively separated from the effects of fire and has indefinite tenability in a station fire event. There are enclosures around the stairs/ escalators and make-up air being drawn down through the stair/escalator openings; this effectively keeps the escape route clear of smoke in a fire event.

For a complete set of the results refer to Appendix H.

Fire Scenario 1 – T1-W 4 MW

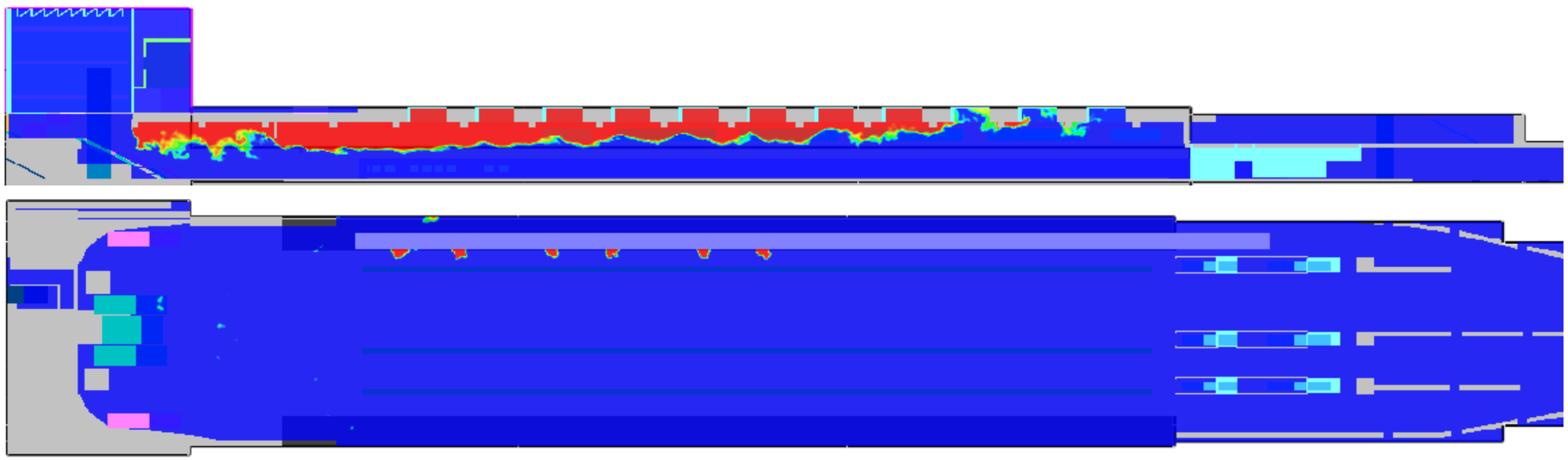
Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (1,200 s).

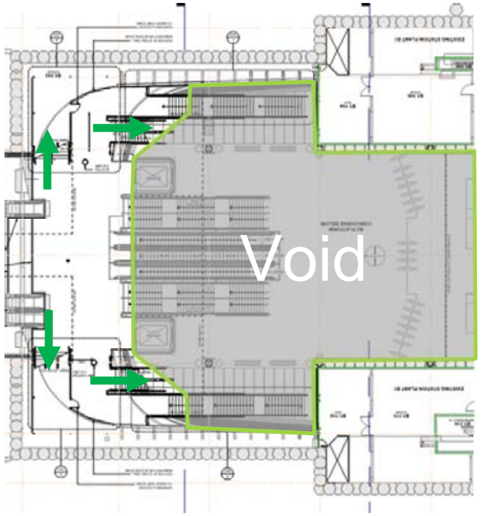
In this fire scenario the tenability is considered to be > 1,200 seconds.

Platform Level

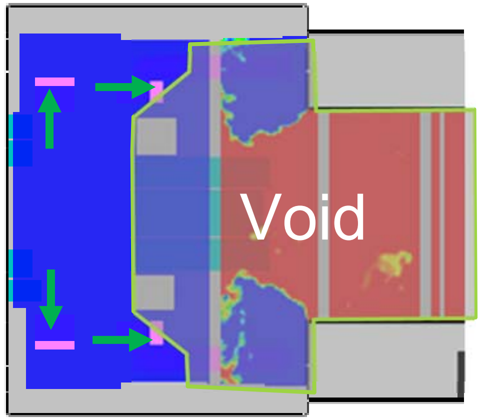


Fire Scenario 1 – T1-W 4 MW

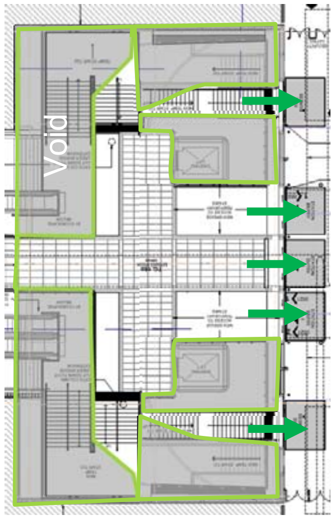
Britomart West Concourse (B1)



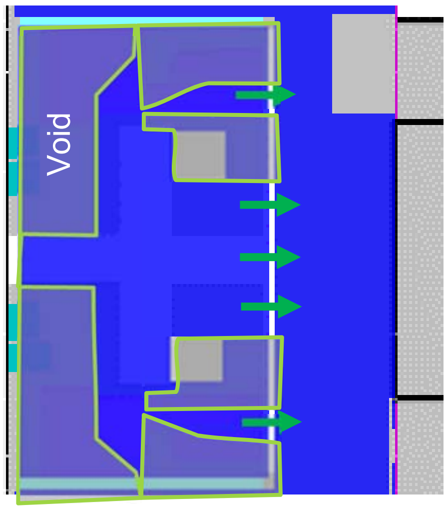
Plan view at 2.0 m above B1 floor level



Glasshouse

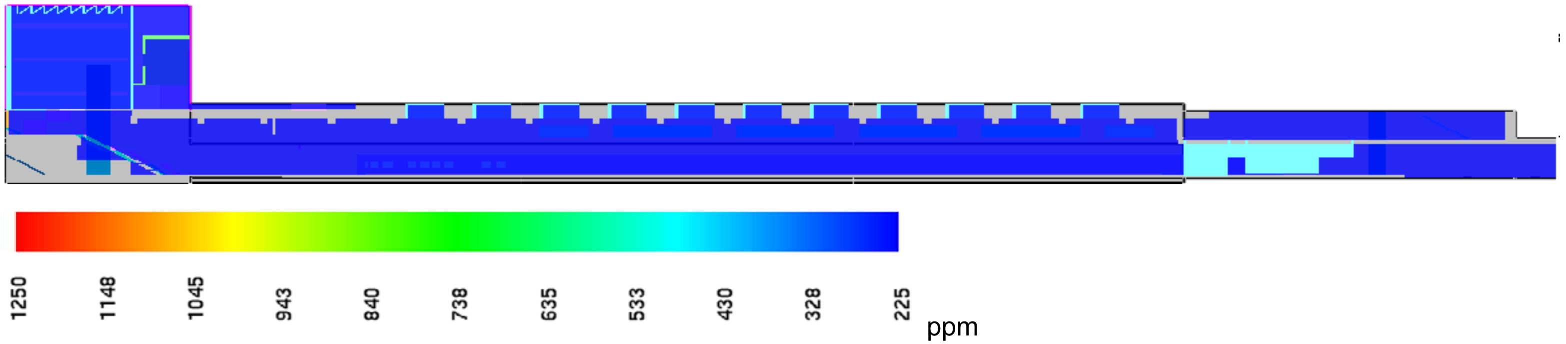


Plan view at 2.0 m above Glasshouse floor level



Fire Scenario 1 – T1-W 4 MW

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

$FED_{CO} = (\varphi_{CO}/35{,}000)*\Delta t$

$FED_{CO} = (225/35{,}000)*20$

$= 0.129$ (≤ 0.3 acceptable).

Fire Scenario 1 – T1-W 4 MW

FED$_{Thermal}$

Tenability limit for FED$_{Thermal}$ is exceeded when the FED$_{Thermal}$ is greater than 0.3

FED$_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

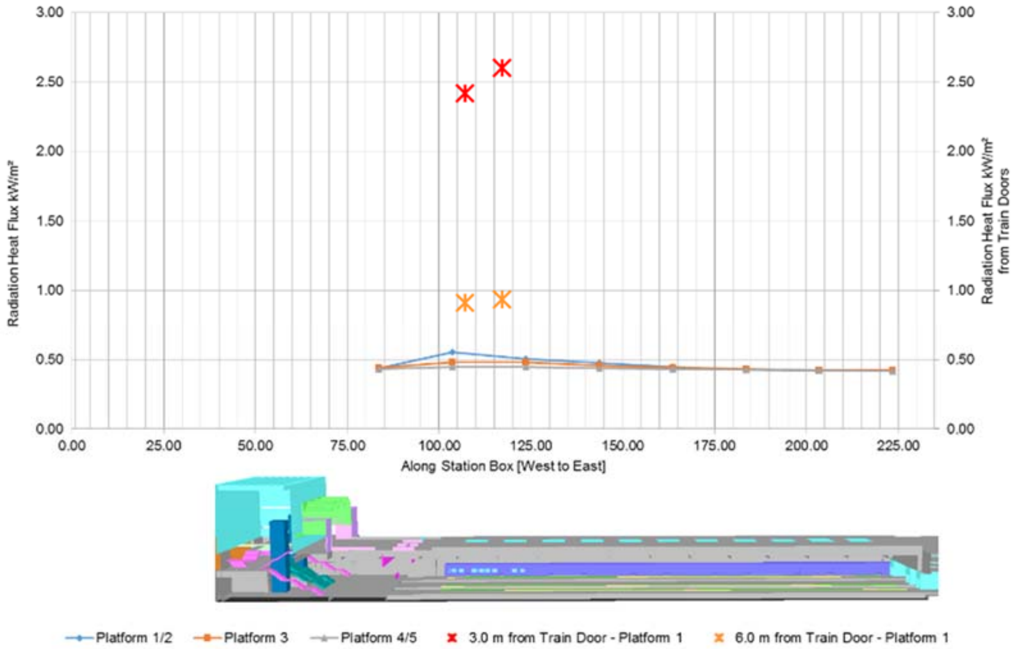
<u>Radiant Heat</u>

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

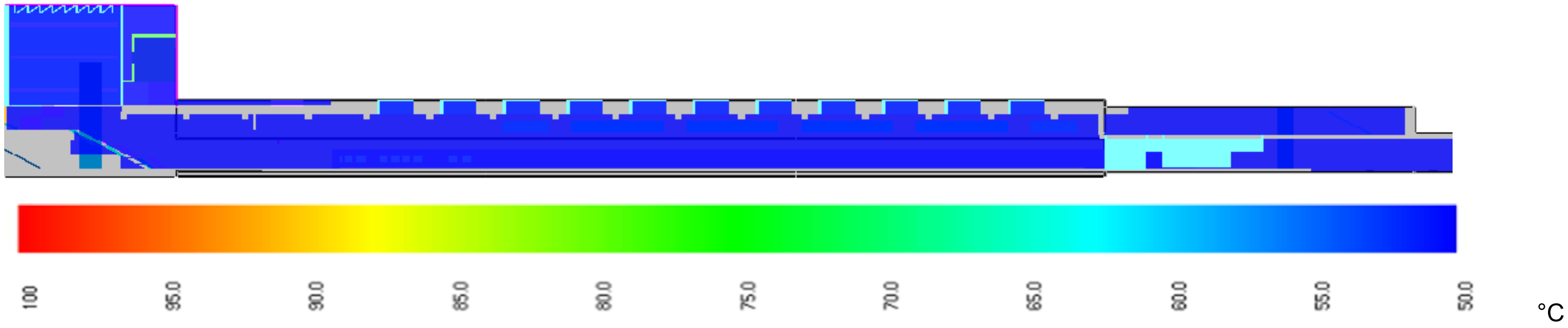
Therefore radiant heat can be discounted in the in FED$_{Thermal}$ calculation.

Radiant heat flux was also measured in front of the open train doors. Occupants can evacuate past the carriage of fire origin along the platform at least 3.0 m from the train door, where they are exposed to a maximum of 2.6 kW/m². Onset of pain occurs after being exposed for $t_p = (35/\dot{q}''_r)^{1.33} = (35/2.6)^{1.33} =$ 32 seconds. Occupants will pass the exposure from the train door in a matter of seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 1 – T1-W 4 MW

<u>Convective Heat</u>



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.064$ ($\leq$ 0.3 acceptable)

Fire Scenario 2 – T3-W 4 MW

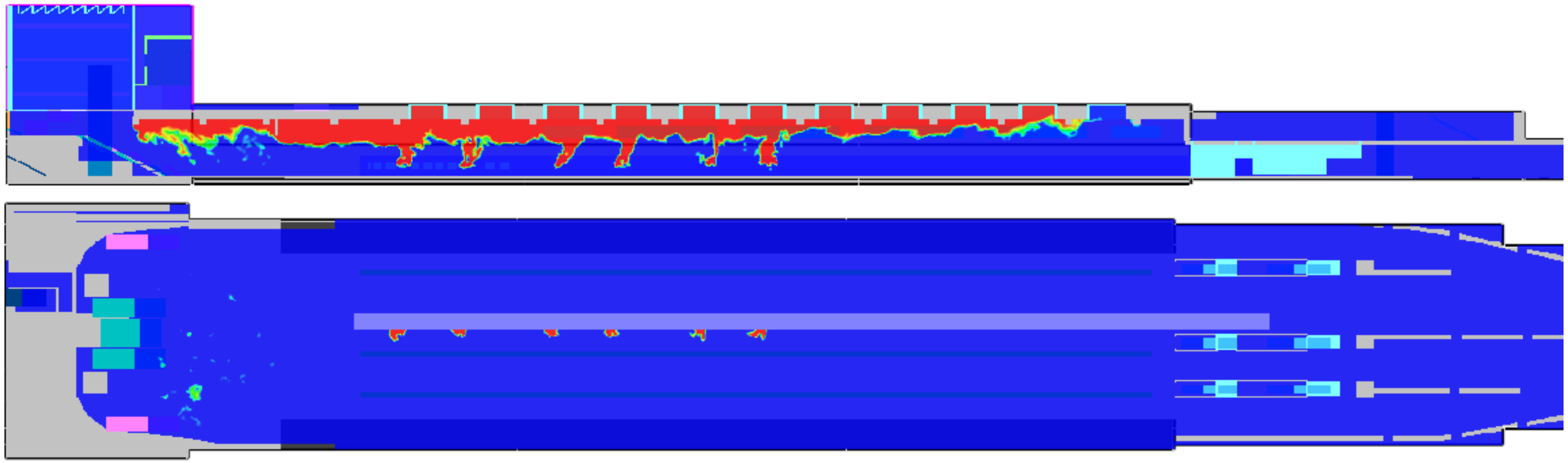
Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (1,200 s).

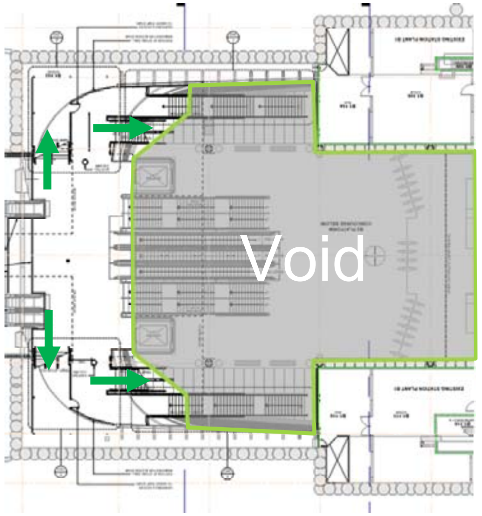
In this fire scenario the tenability is considered to be > 1,200 seconds.

Platform Level

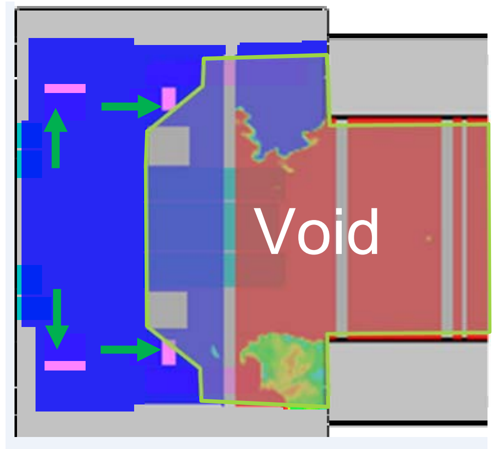


Fire Scenario 2 – T3-W 4 MW

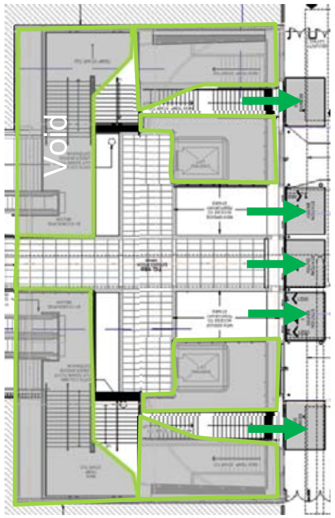
Britomart West Concourse (B1)



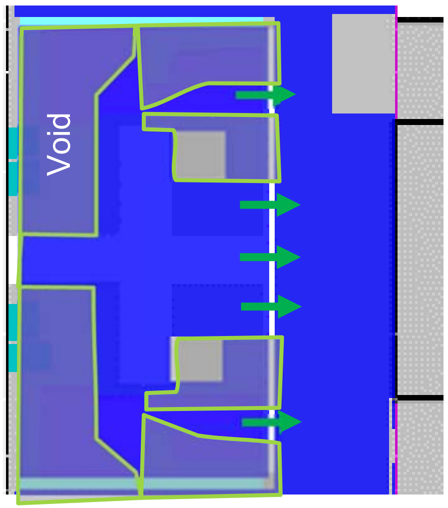
Plan view at 2.0 m above B1 floor level



Glasshouse

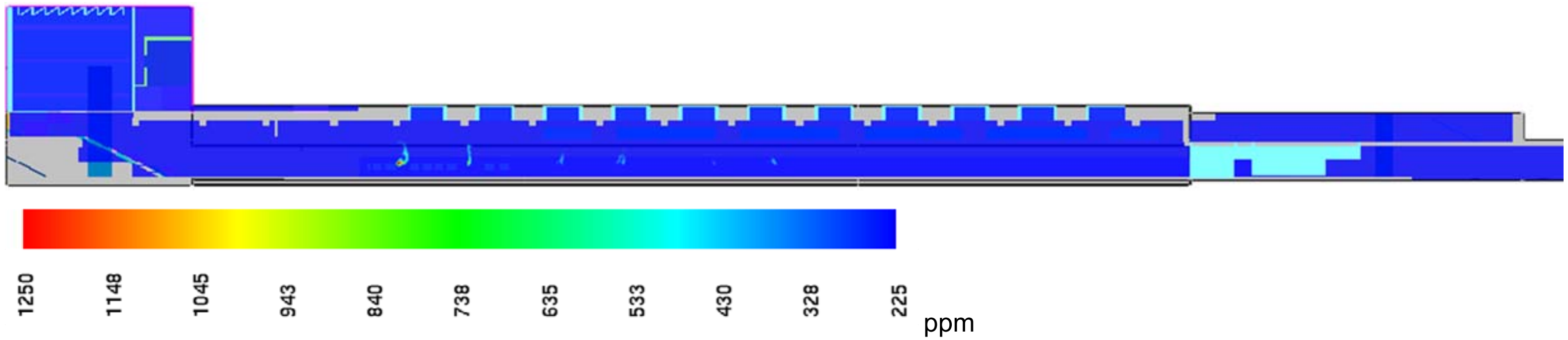


Plan view at 2.0 m above Glasshouse floor level



Fire Scenario 2 – T3-W 4 MW

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

$FED_{CO} = (\varphi_{CO}/35,000)*\Delta t$

$FED_{CO} = (225/35,000)*20$

$= 0.129$ (≤ 0.3 acceptable).

Fire Scenario 2 – T3-W 4 MW

$FED_{Thermal}$

Tenability limit for $FED_{Thermal}$ is exceeded when the $FED_{Thermal}$ is greater than 0.3

$FED_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 KW/m²

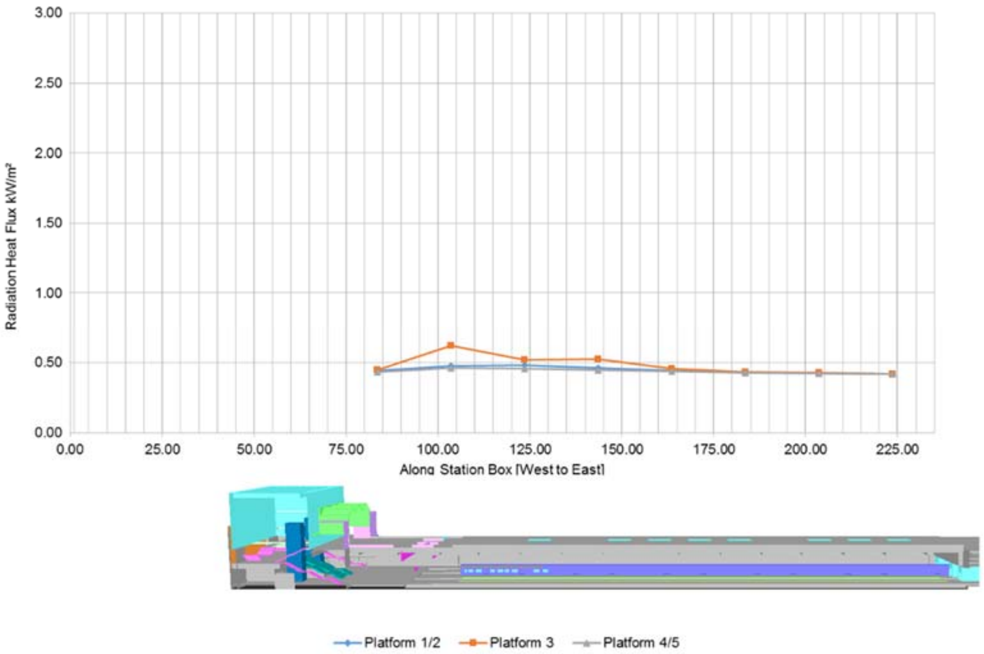
Radiant Heat

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

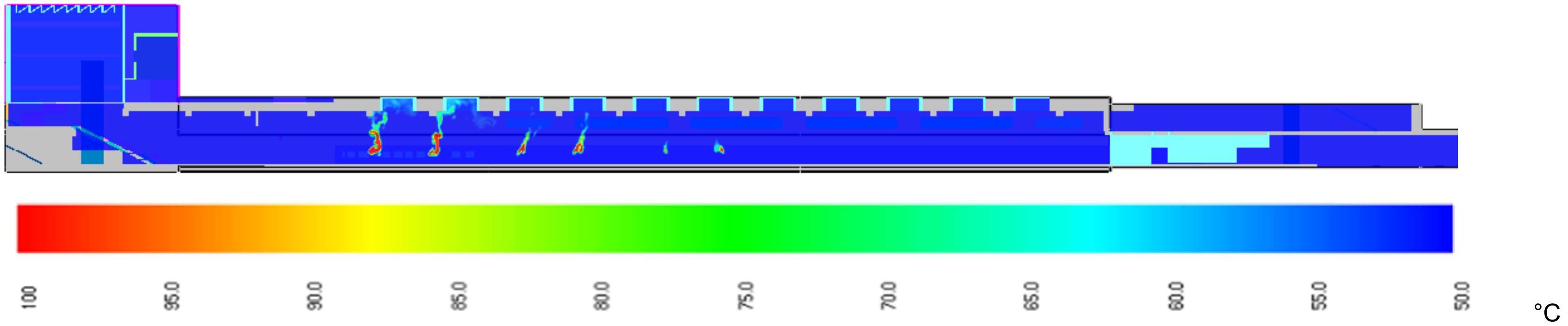
Therefore radiant heat can be discounted in the in $FED_{Thermal}$ calculation.

As the design fire is the same as Fire Scenario 1 the radiant heat flux in front of the doors will be the same. Occupants can evacuate past the carriage of fire origin along the platform at least 3.0 m from the train door, where they are exposed to a maximum of 2.6 kW/m². Onset of pain occurs after being exposed for $t_p = (35/\dot{q}''_r)^{1.33} = (35/2.6)^{1.33} = 32$ seconds. Occupants will pass the exposure from the train door in a matter of seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 2 – T3-W 4 MW

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.064$ ($\leq$ 0.3 acceptable)

Fire Scenario 3 – T1-E 4 MW

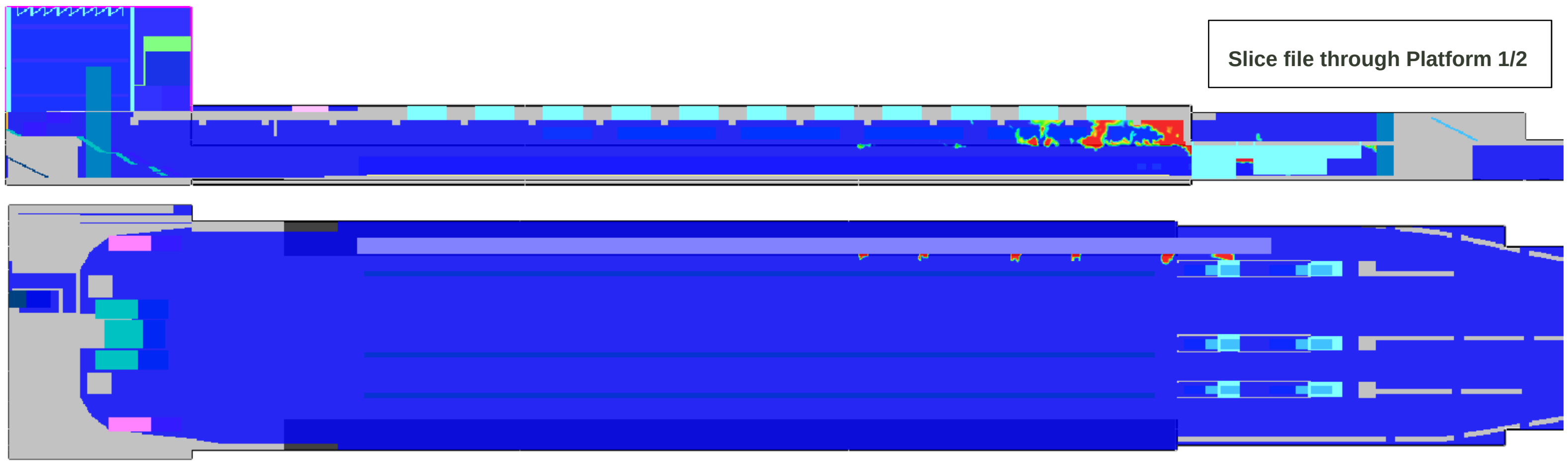
Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (1,110 s).

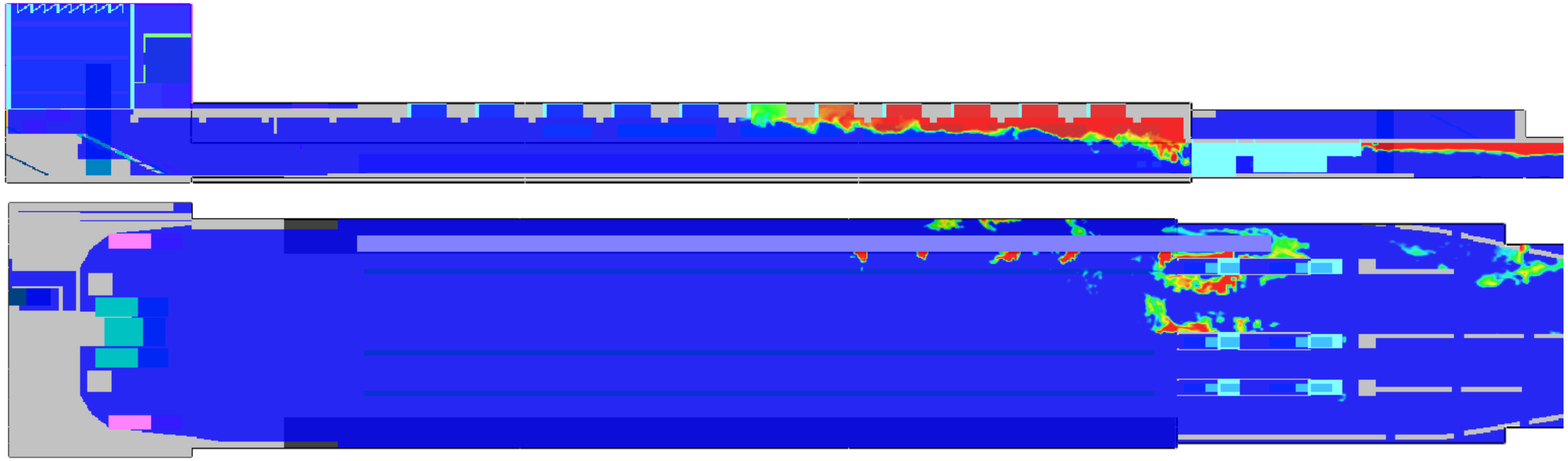
In this fire scenario the tenability is considered to be > 1,110 seconds, except the Platform 1/2 exits at Britomart East which are directly in front of the fire location. Based on Egress Case 4 the clearance time of Platform 1/2 is calculated to be 57 seconds[JA1]

Platform Level: 60 seconds

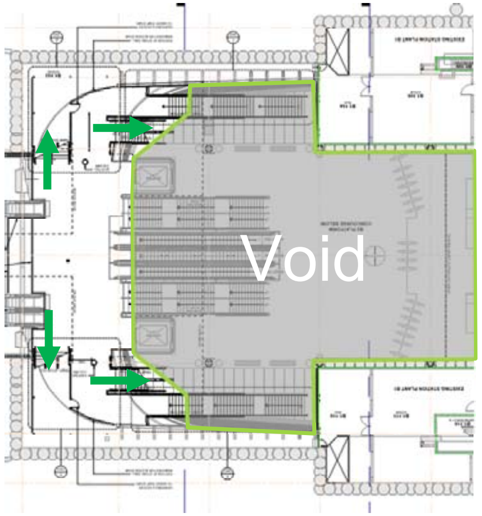
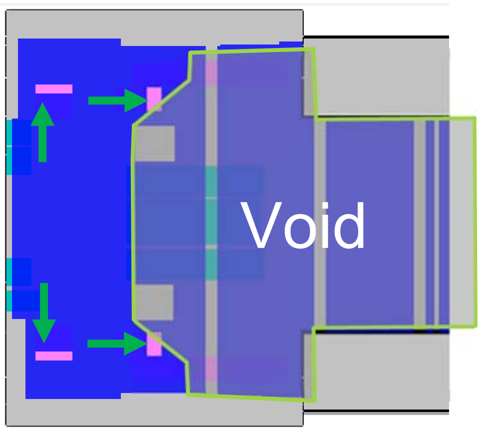
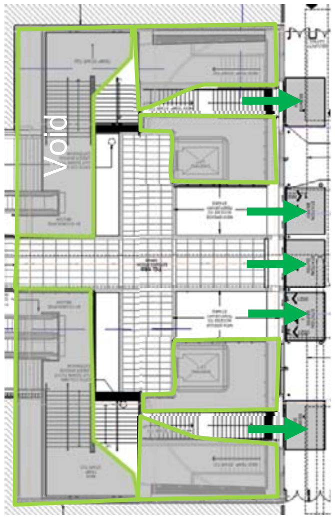
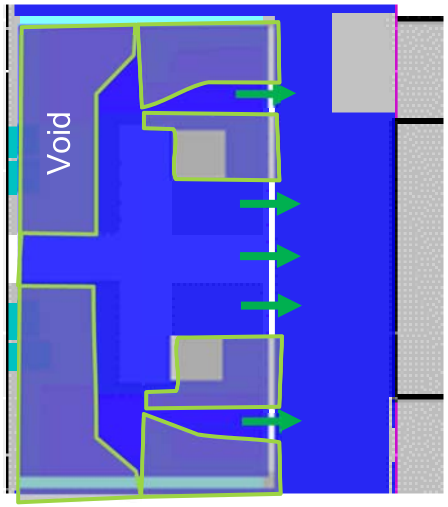


Fire Scenario 3 – T1-E 4 MW

Platform Level: 1,110 seconds

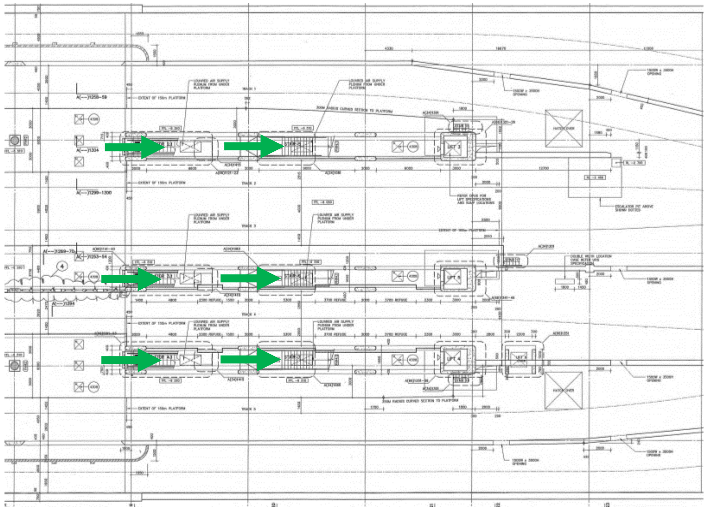


Fire Scenario 3 – T1-E 4 MW

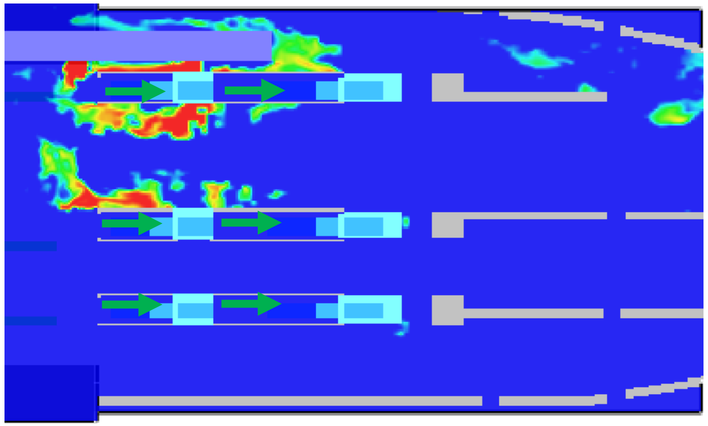
Britomart West Concourse (B1)	Plan view at 2.0 m above B1 floor level: 1,110 seconds
	
Glasshouse	**Plan view at 2.0 m above Glasshouse floor level: 1,110 seconds**
	

Fire Scenario 3 – T1-E 4 MW

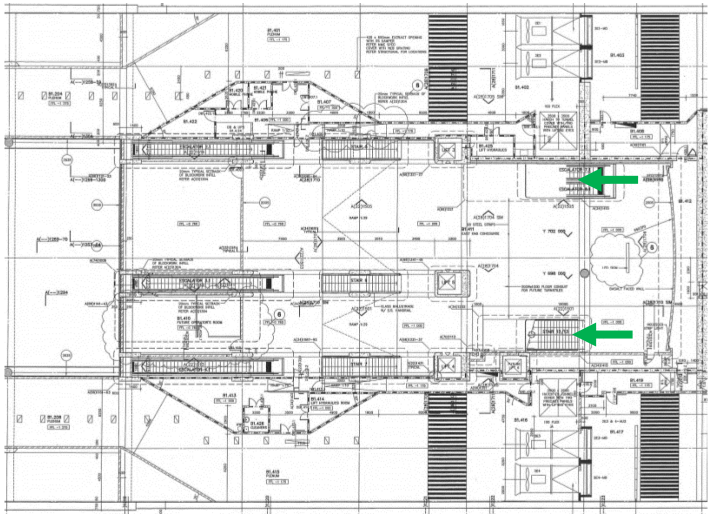
Britomart East Platform



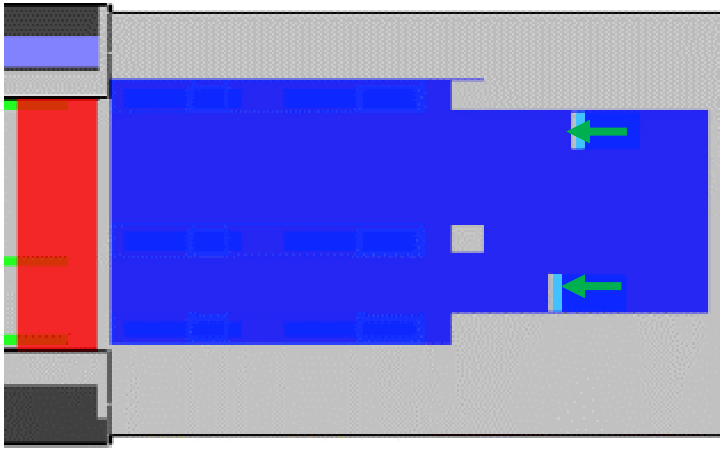
Plan view at 2.0 m above Platform floor level: 1,110 seconds



Britomart East Concourse (B1)

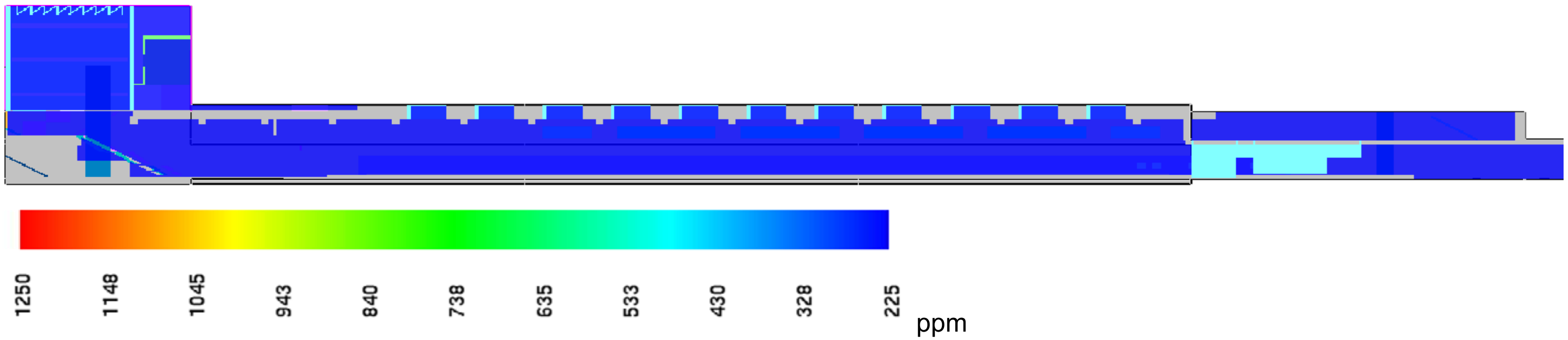


Plan view at 2.0 m above B1 floor level: 1,110 seconds



Fire Scenario 3 – T1-E 4 MW

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,110 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (18.5 minutes)

FED_{CO} = $(\varphi_{CO}/35{,}000)*\Delta t$

FED_{CO} = (225/35,000)*18.5

= 0.119 ($\leq$ 0.3 acceptable).

Fire Scenario 3 – T1-E 4 MW

FED$_{Thermal}$

Tenability limit for FED$_{Thermal}$ is exceeded when the FED$_{Thermal}$ is greater than 0.3

FED$_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 KW/m²

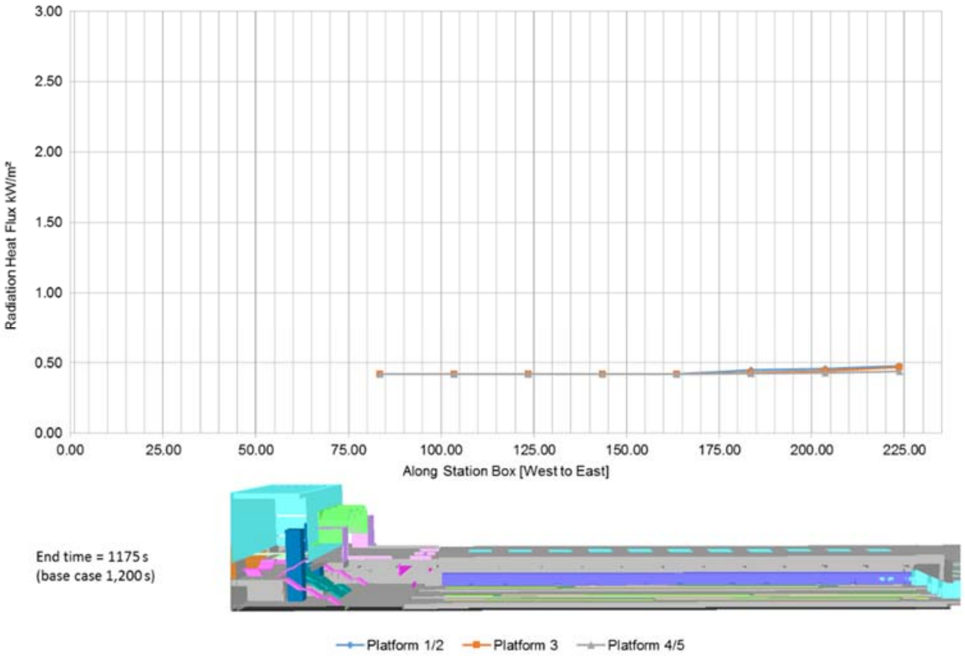
Radiant Heat

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,110 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

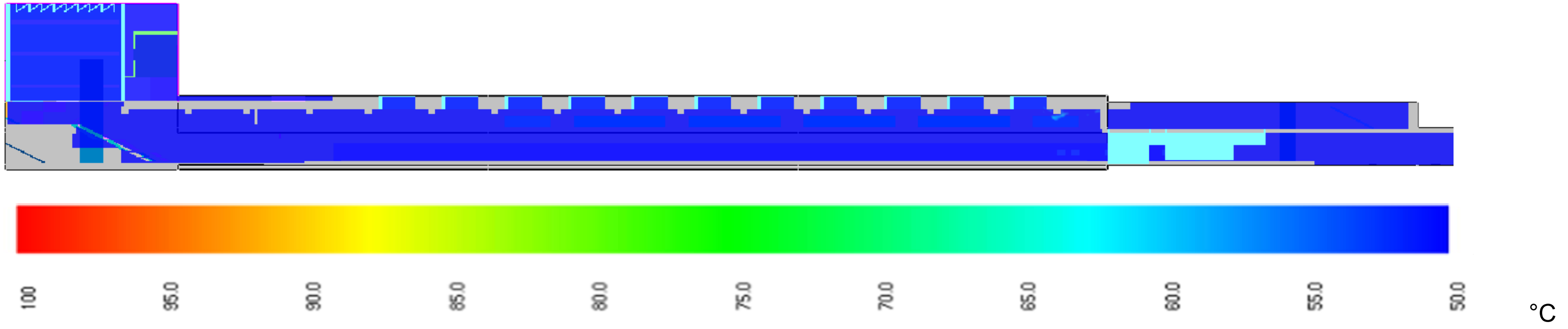
Therefore radiant heat can be discounted in the in FED$_{Thermal}$ calculation.

As the design fire is the same as Fire Scenario 1 the radiant heat flux in front of the doors will be the same. However as the exits are directly in front of the design fire is it unlikely occupants will pass the fire to reach an exit. Egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 3 – T1-E 4 MW

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,110 seconds / 18.5 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.059\ (\leq 0.3\ \text{acceptable})$

Fire Scenario 4 – T3-E 4 MW

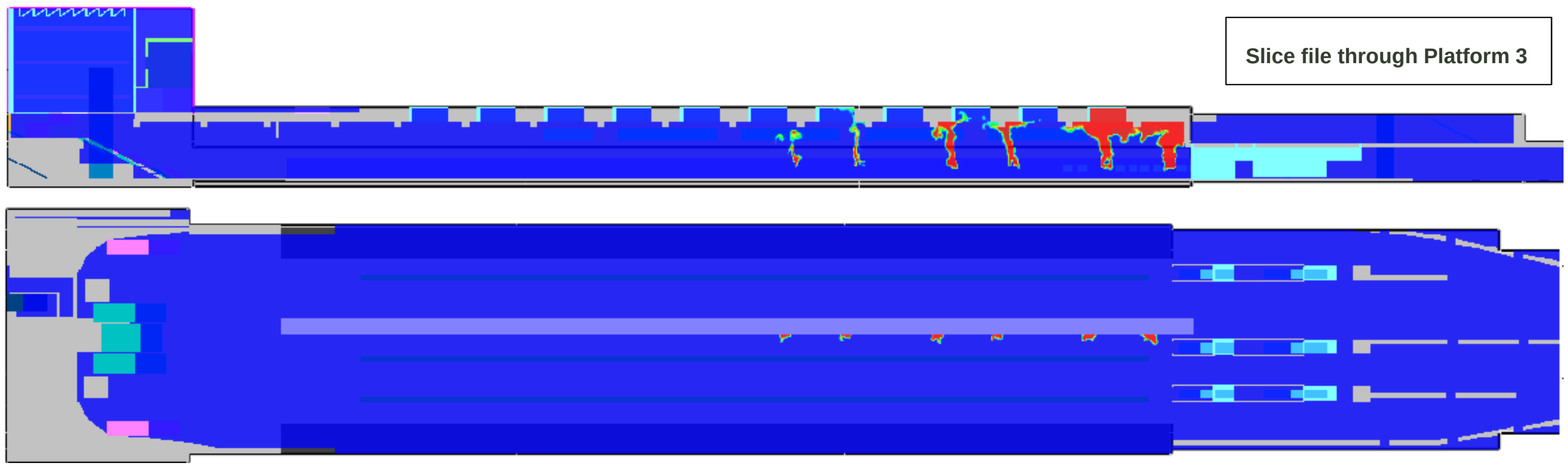
Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (1,200 s).

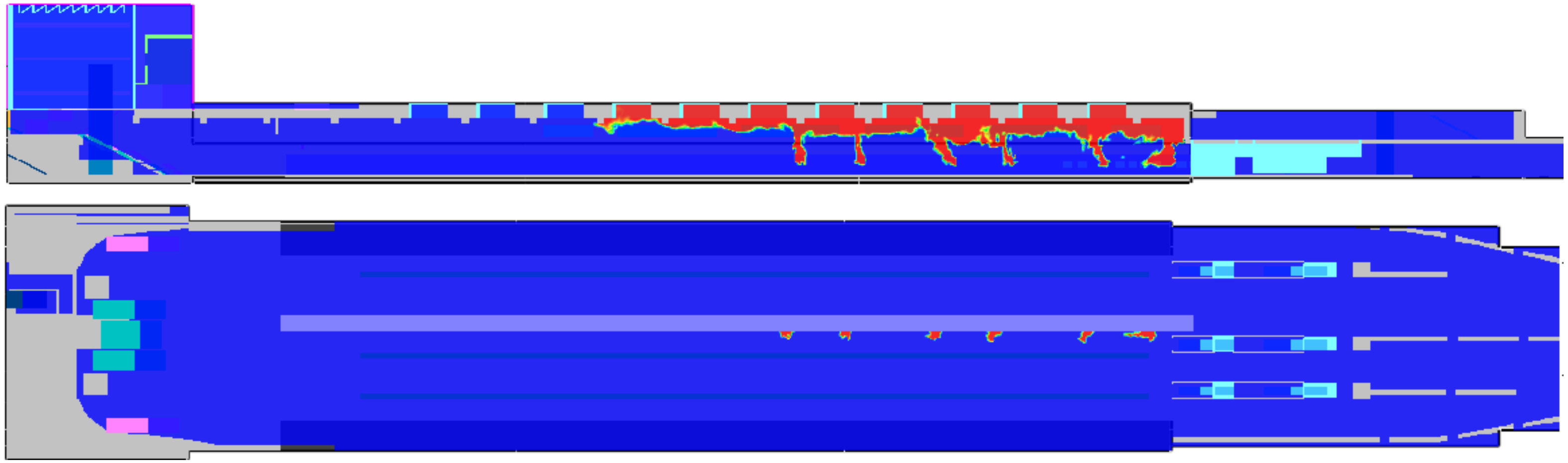
In this fire scenario the tenability is considered to be > 1,200 seconds, except the Platform 3 exits at Britomart East which are directly in front of the fire location. Based on Egress Case 5the clearance time of Platform 1/2 is calculated to be 48 seconds

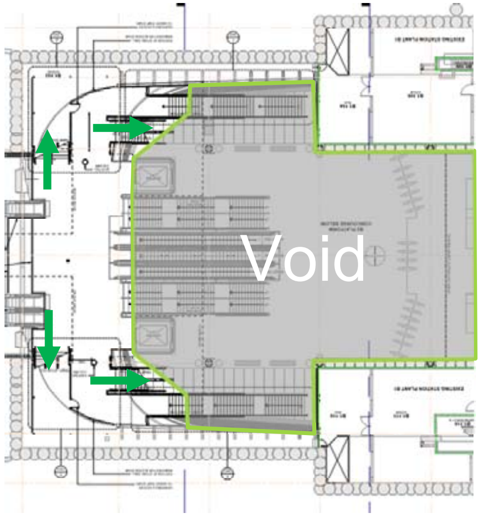
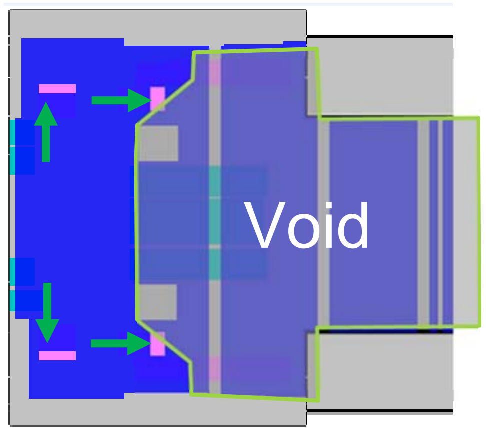
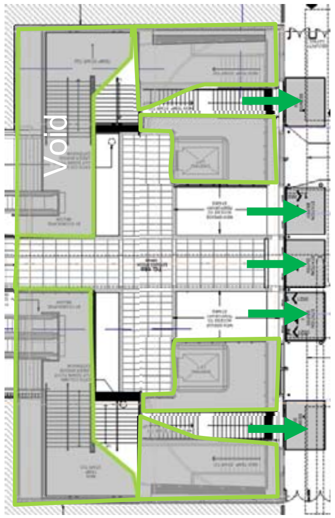
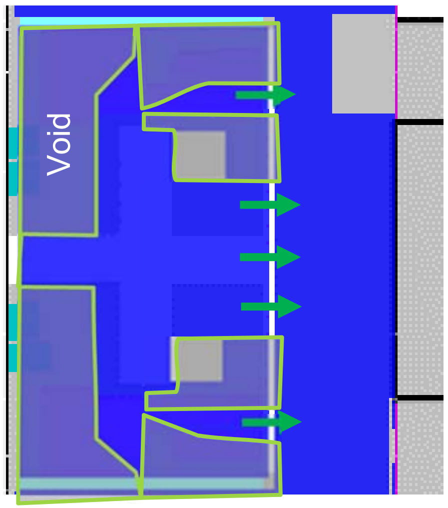
Platform Level: 60 seconds



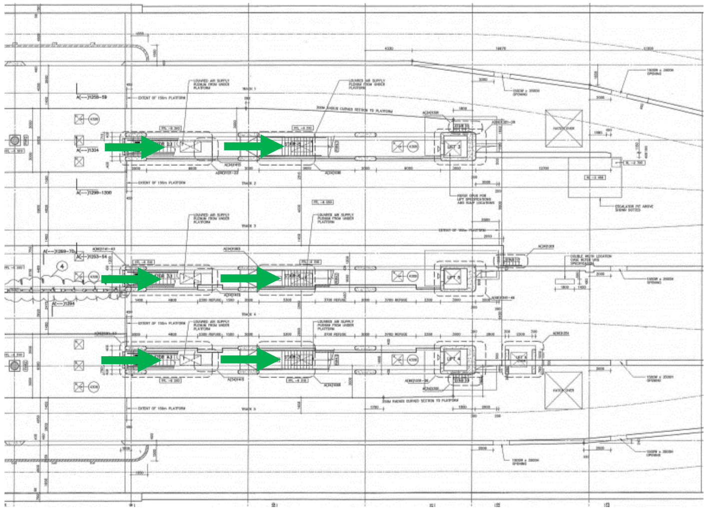
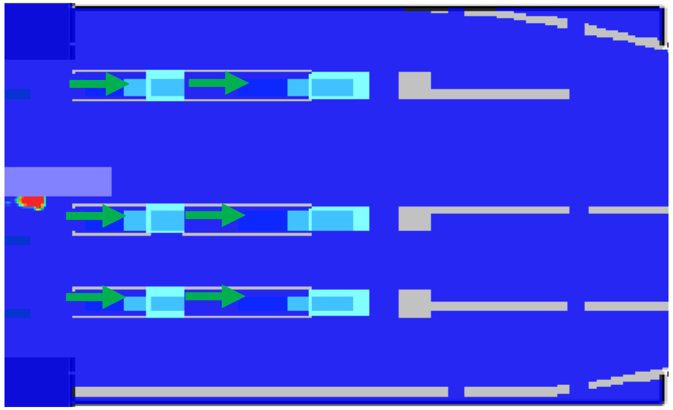
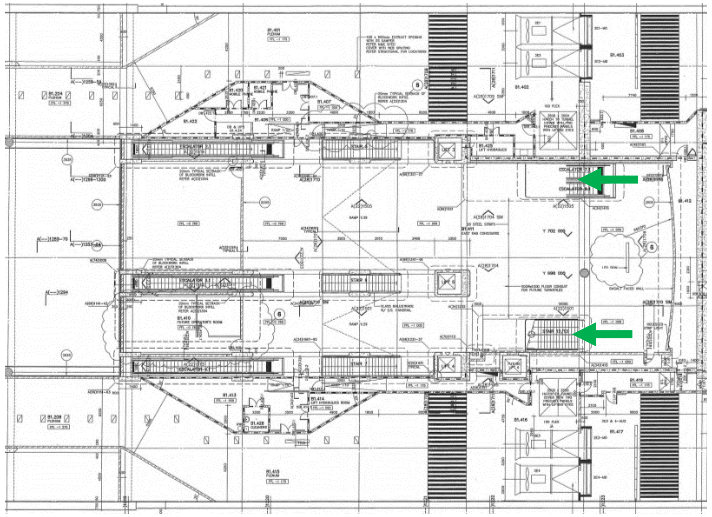
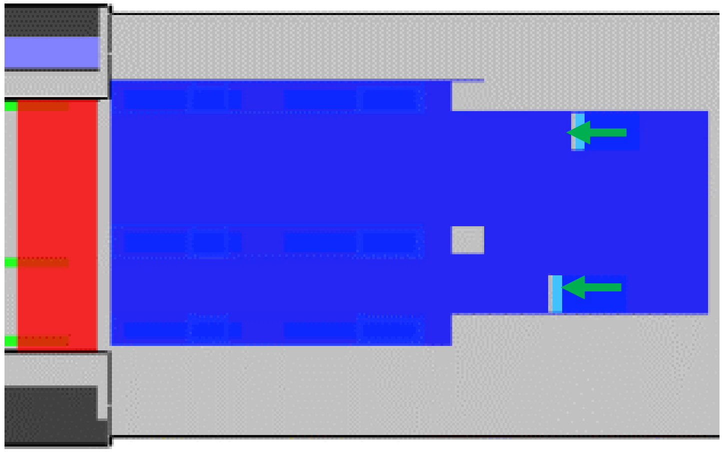
Fire Scenario 4 – T3-E 4 MW

Platform Level: 1,200 seconds



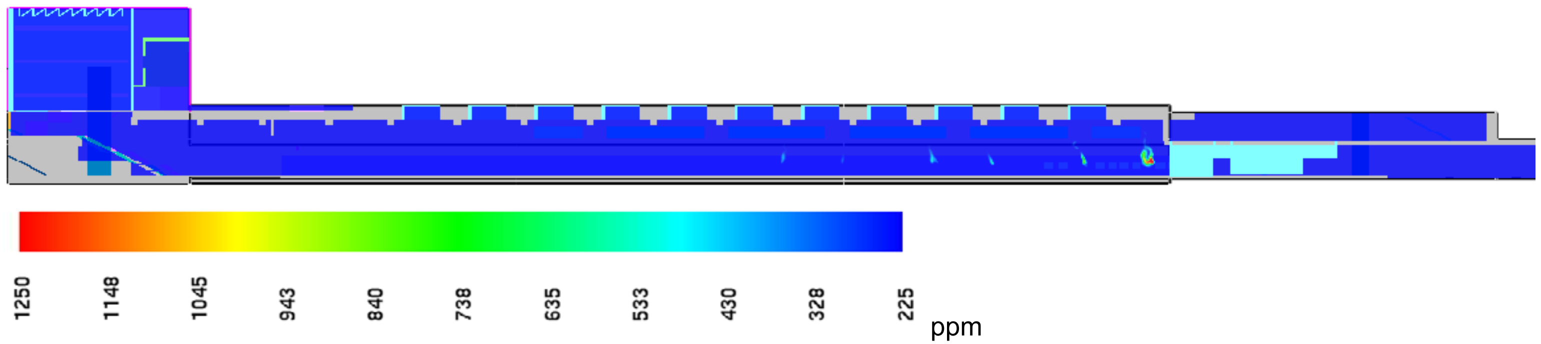
Fire Scenario 4 – T3-E 4 MW	
Britomart West Concourse (B1) 	Plan view at 2.0 m above B1 floor level: 1,200 seconds 
Glasshouse 	Plan view at 2.0 m above Glasshouse floor level: 1,200 seconds 

Fire Scenario 4 – T3-E 4 MW

Britomart East Platform	Plan view at 2.0 m above Platform floor level: 1,200 seconds
	
Britomart East Concourse (B1)	**Plan view at 2.0 m above B1 floor level: 1,200 seconds**
	

Fire Scenario 4 – T3-E 4 MW

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

$FED_{CO} = (\varphi_{CO}/35{,}000)*\Delta t$

$FED_{CO} = (225/35{,}000)*20$

$= 0.129$ (≤ 0.3 acceptable).

Fire Scenario 4 – T3-E 4 MW

$FED_{Thermal}$

Tenability limit for $FED_{Thermal}$ is exceeded when the $FED_{Thermal}$ is greater than 0.3

$FED_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 KW/m²

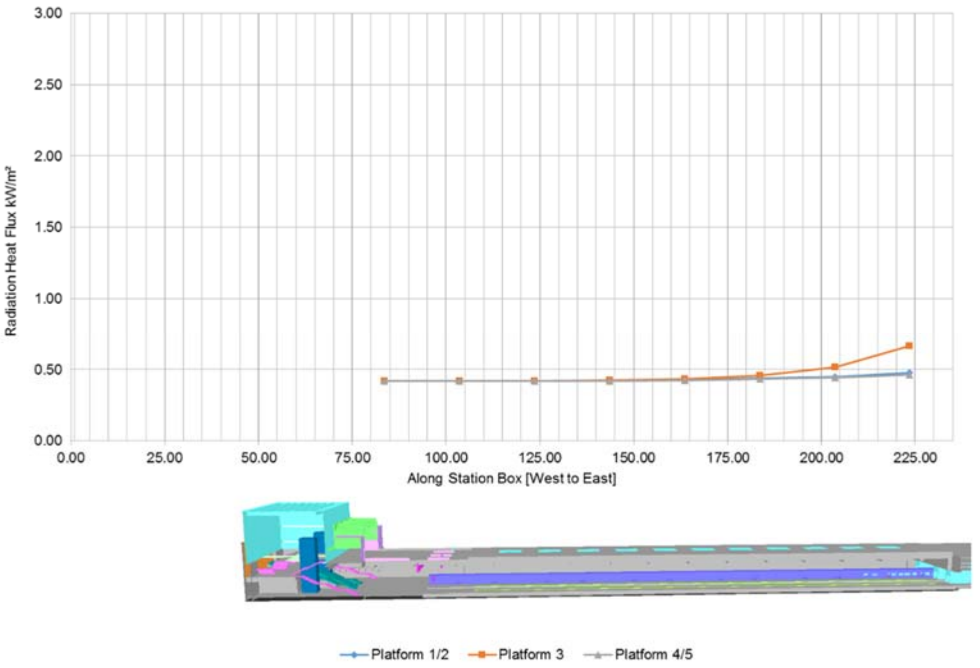
Radiant Heat

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

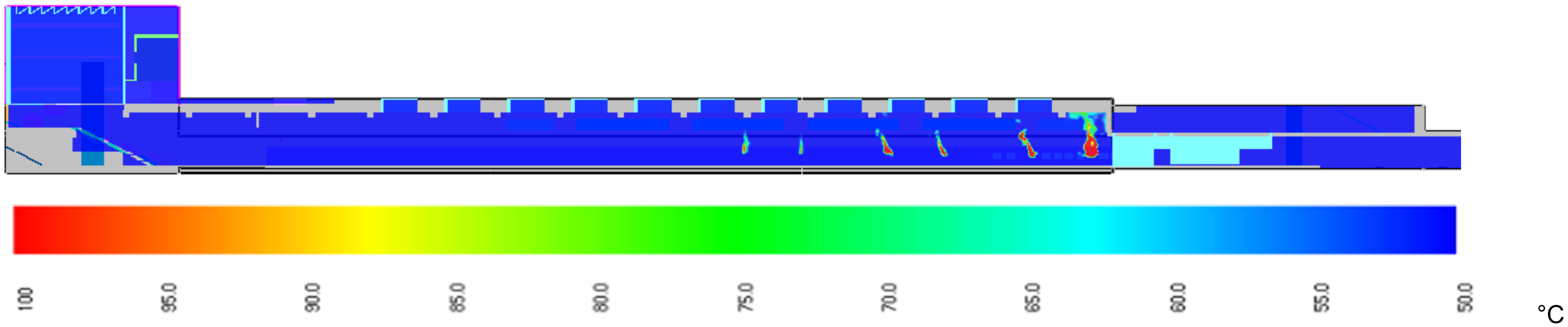
Therefore radiant heat can be discounted in the in $FED_{Thermal}$ calculation.

As the design fire is the same as Fire Scenario 1 the radiant heat flux in front of the doors will be the same. However as the exits are directly in front of the design fire is it unlikely occupants will pass the fire to reach an exit. Egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 4 – T3-E 4 MW

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.064$ ($\leq$ 0.3 acceptable)

Fire Scenario 5 – T1-W 10 MW

Visibility

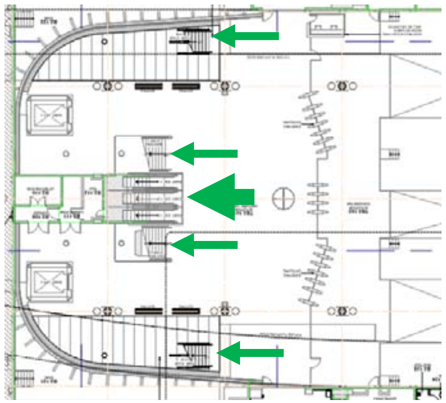
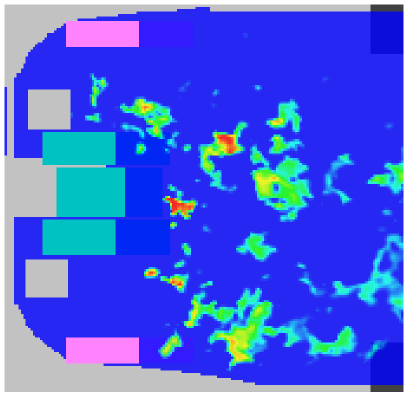
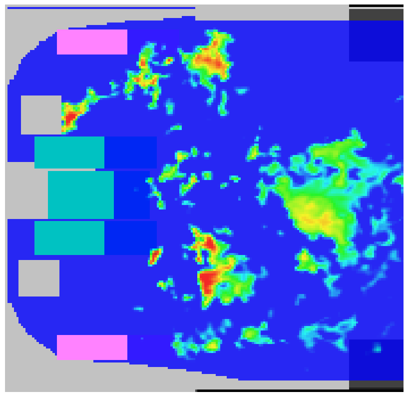
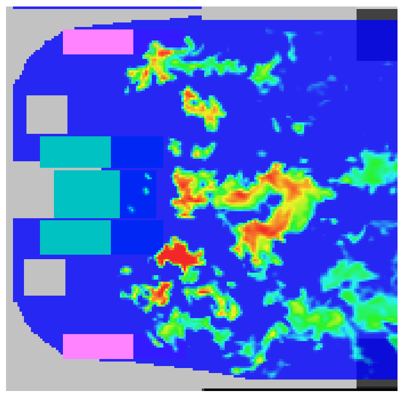
m

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded is demonstrated by the 30 seconds prior to the nominated ASET, and the nominated ASET and 30 seconds after the nominated ASET.

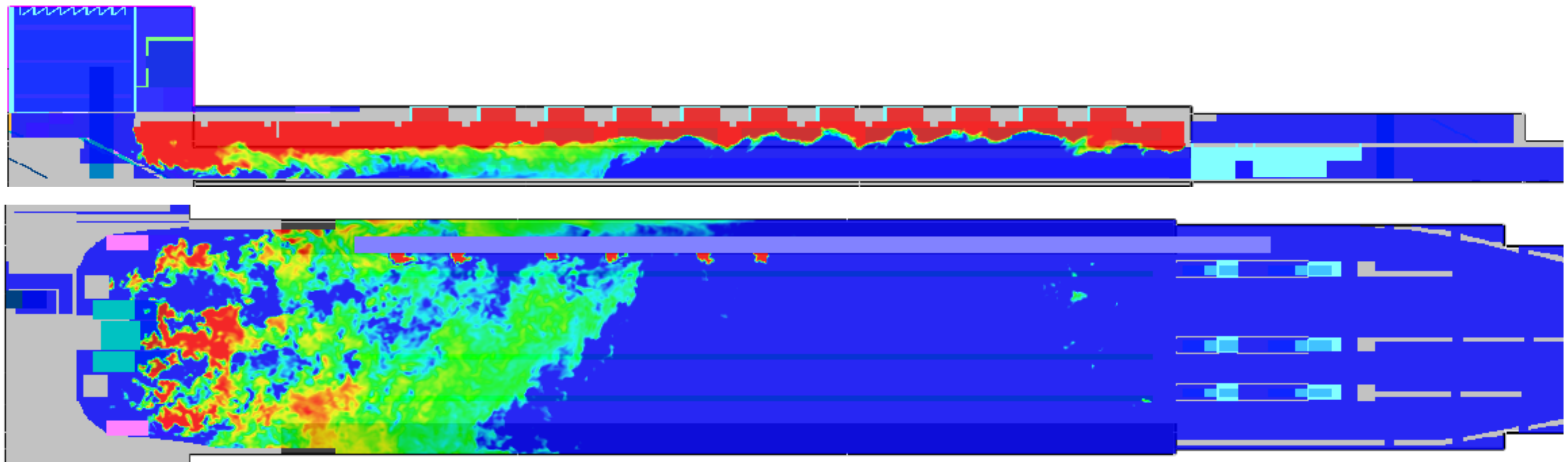
In this fire scenario the tenability criteria is considered to be exceeded on Platform Level (B2) at 720 seconds.

Tenability is considered to be maintained for > 1,200 seconds in all other areas.

Platform Level: Britomart West Exits	T = 690 seconds	T = 720 seconds	T = 750 seconds
			

Fire Scenario 5 – T1-W 10 MW

Platform Level: T = 1,200 seconds



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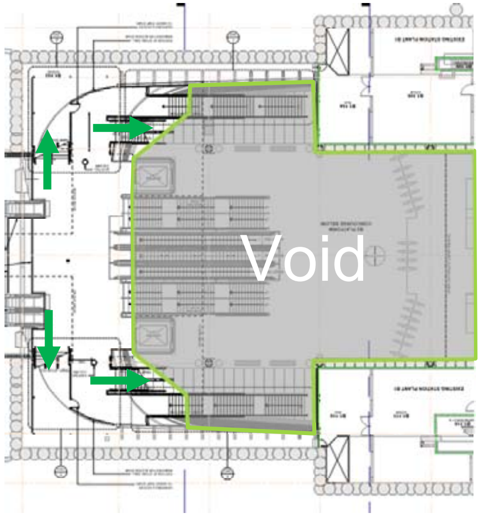
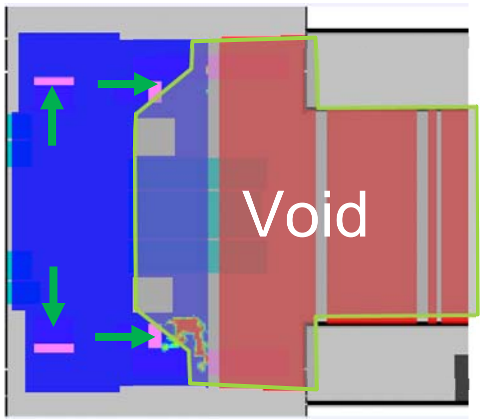
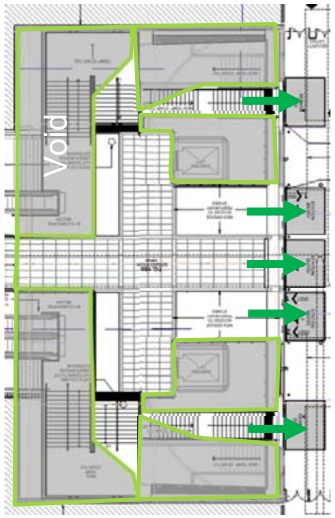
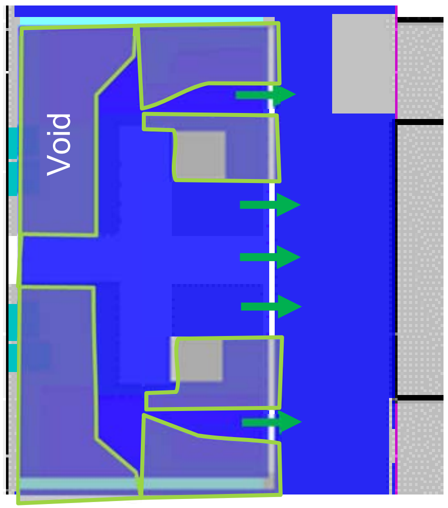
<tr><th colspan="2">Fire Scenario 5 – T1-W 10 MW</th></tr>
<tr><td>Britomart West Concourse (B1)

</td><td>Plan view at 2.0 m above B1 floor level: 1,200 seconds

</td></tr>
<tr><td>Glasshouse

</td><td>Plan view at 2.0 m above Glasshouse floor level: 1,200 seconds

</td></tr>
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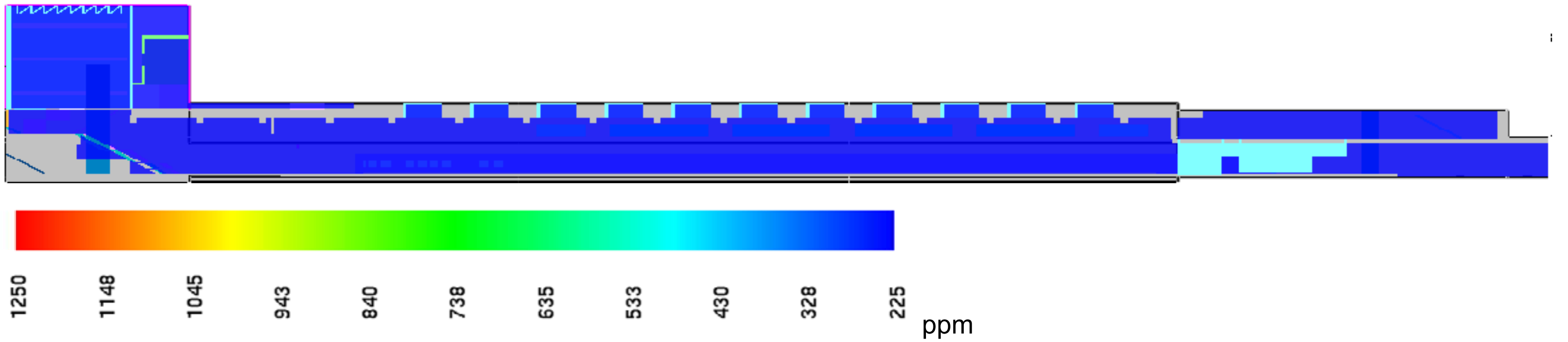
Fire Scenario 5 – T1-W 10 MW

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

$FED_{CO} = (\varphi_{CO}/35{,}000)*\Delta t$

$FED_{CO} = (225/35{,}000)*20$

$= 0.129$ ($\leq$ 0.3 acceptable).

Fire Scenario 5 – T1-W 10 MW

FED$_{Thermal}$

Tenability limit for FED$_{Thermal}$ is exceeded when the FED$_{Thermal}$ is greater than 0.3

FED$_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

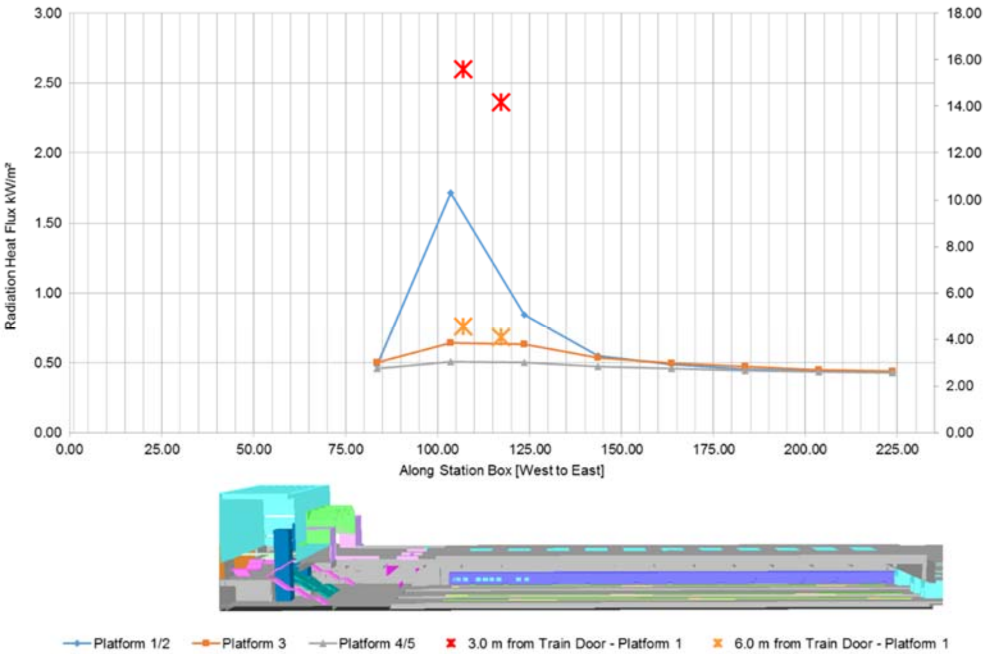
Radiant Heat

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

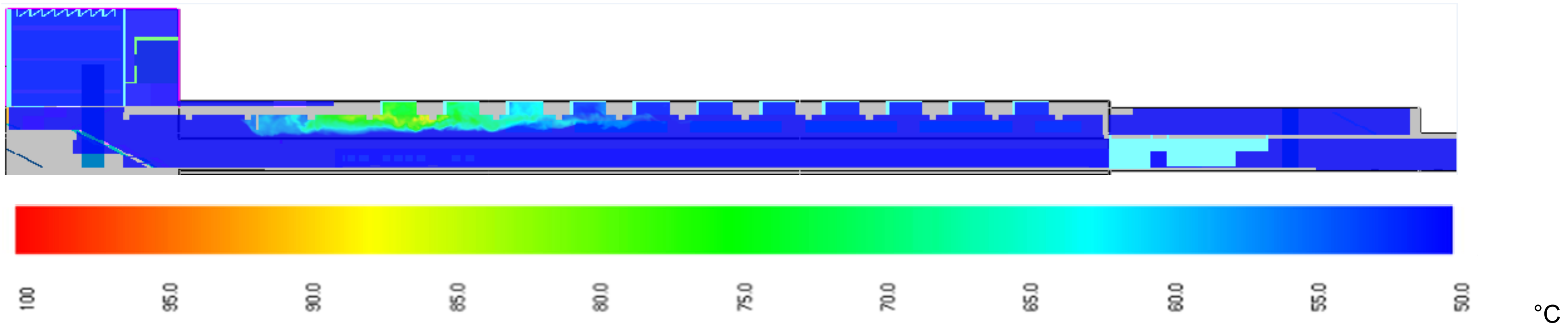
Therefore radiant heat can be discounted in the in FED$_{Thermal}$ calculation.

Radiant heat flux was also measure in front of the open train doors. Occupants on Platform ½ cannot evacuate past the carriage of fire origin along the platform as the radiant heat flux 3.0 m from the train door is 15.6 kW/m², this exceeds the maximum permissible under PD 7974: Part 6 of 10 kW/m², which causes onset of pain in 4 seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 5 – T1-W 10 MW

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.064$ ($\leq$ 0.3 acceptable)

Fire Scenario 6 – T1-W 4 MW with 50% exhaust

Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m

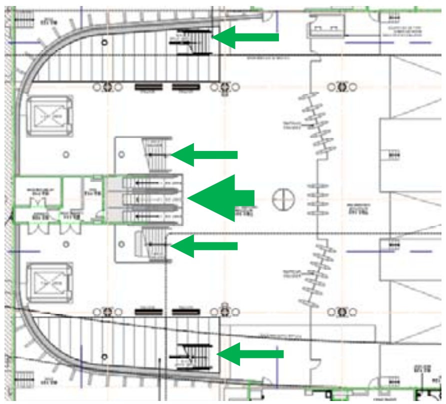
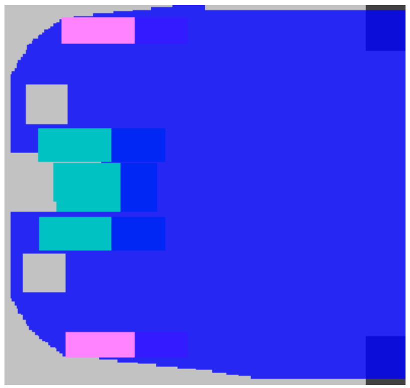
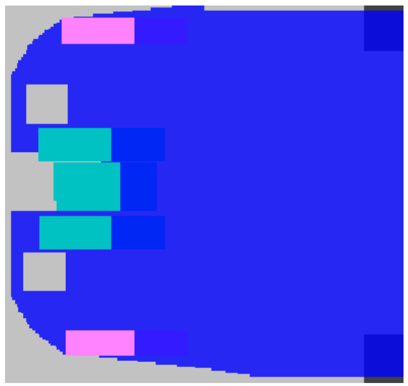
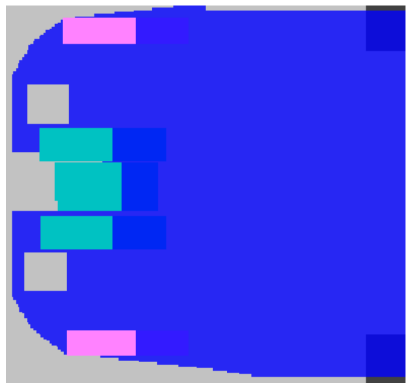
The period where the tenability criteria is exceeded is demonstrated by the 30 seconds prior to the nominated ASET, and the nominated ASET and 30 seconds after the nominated ASET.

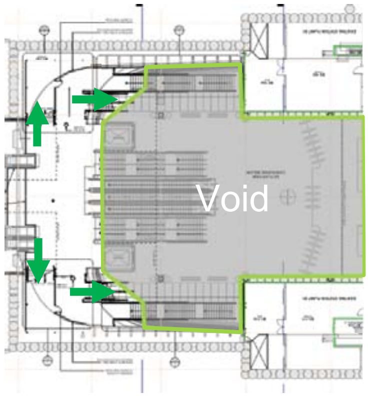
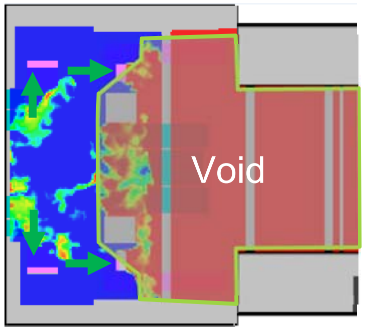
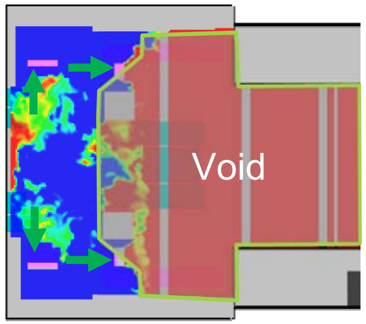
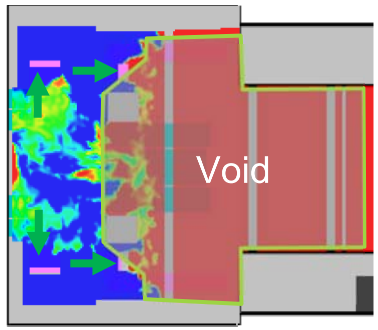
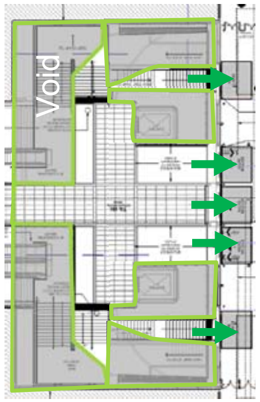
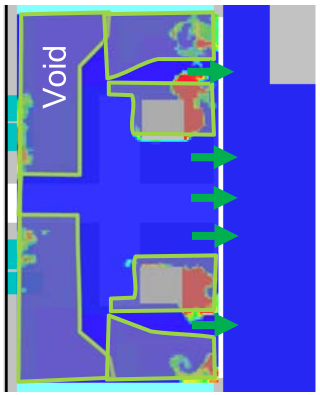
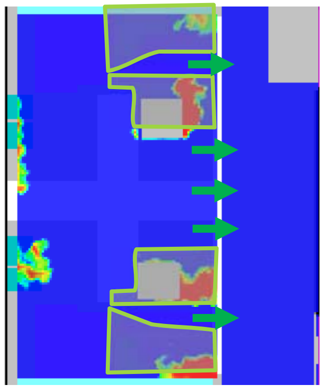
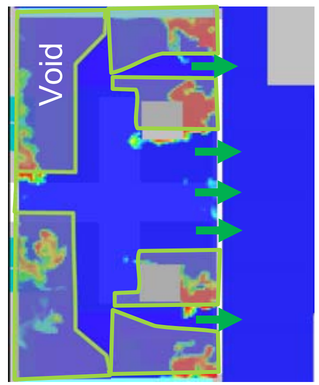
In this fire scenario the tenability criteria is considered to be exceeded on:

- Platform Level (B2) at 588 seconds.
- Concourse Level (B1) at 318 seconds
- Glasshouse (GH) at 384 seconds

As occupants are required to pass through all three spaces to evacuate Britomart West, Britomart West ASET is considered to be 318 seconds

Tenability is considered to be maintained for > 846 seconds from Britomart East.

B2: Britomart West Exits	T = 288 seconds	T = 318 seconds	T = 348 seconds
			

<table>
<tr><th colspan="4">Fire Scenario 6 – T1-W 4 MW with 50% exhaust</th></tr>
<tr><td>Britomart West Concourse (B1)</td><td>T = 288 seconds</td><td>T = 318 seconds</td><td>T = 348 seconds</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Glasshouse</td><td>T = 288 seconds</td><td>T = 318 seconds</td><td>T = 348 seconds</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
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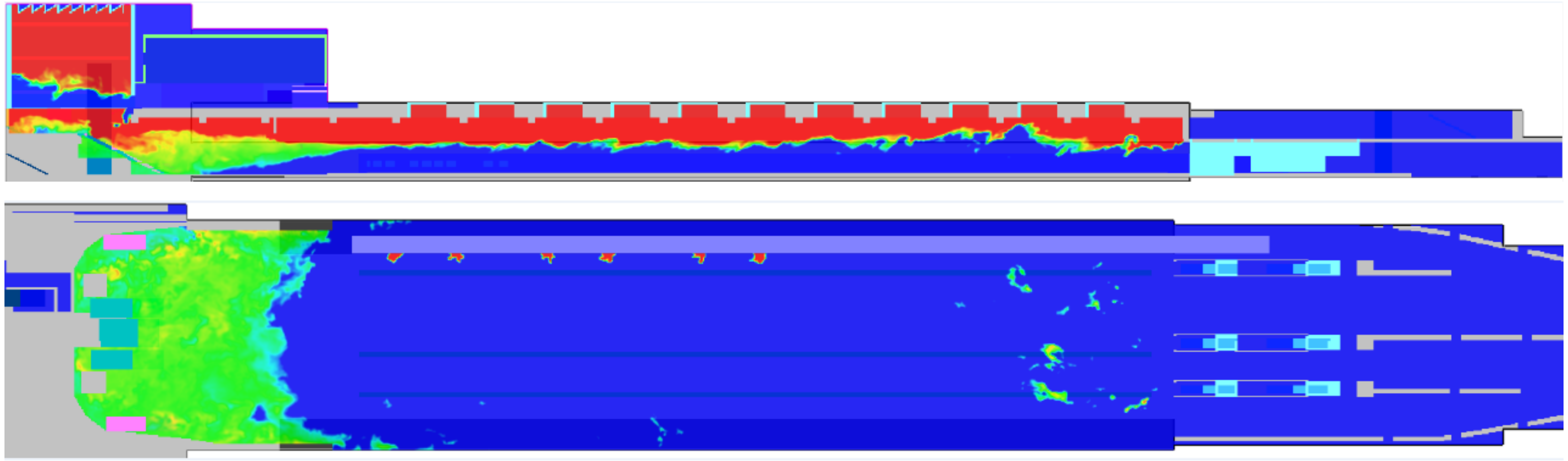
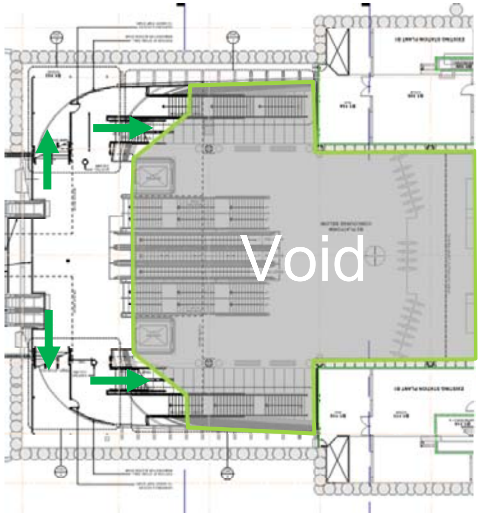
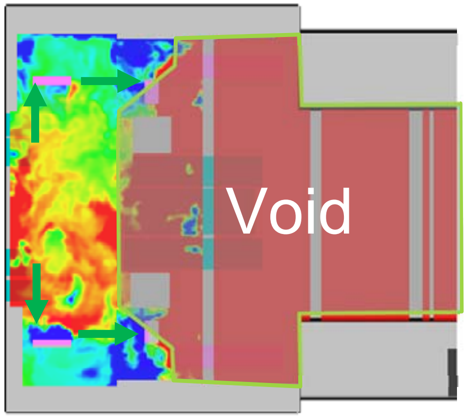
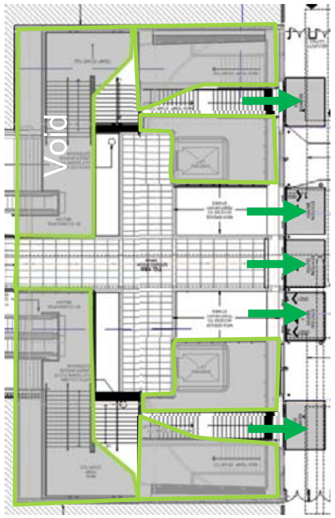
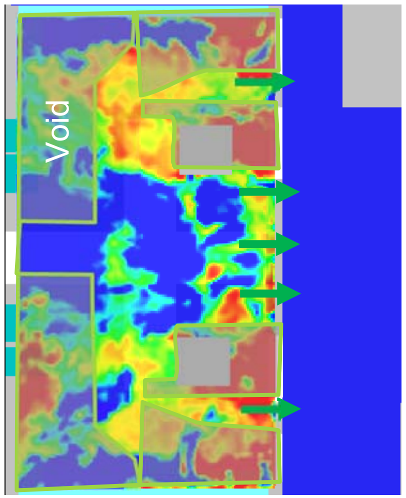
Fire Scenario 6 – T1-W 4 MW with 50% exhaust

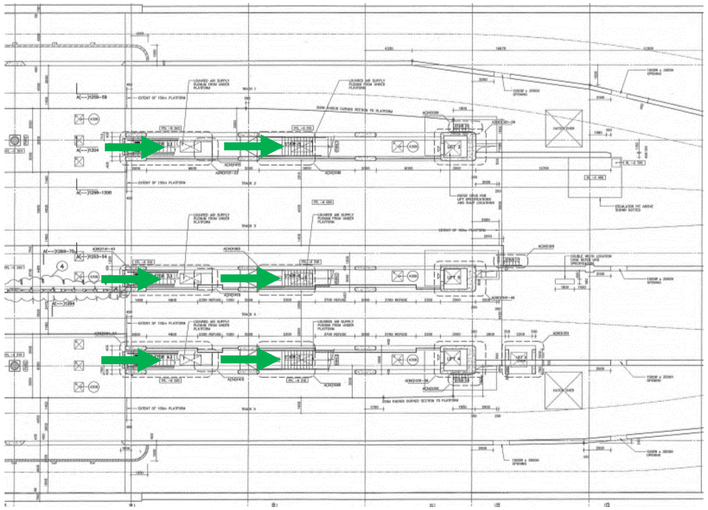
Platform Level: T = 846 seconds



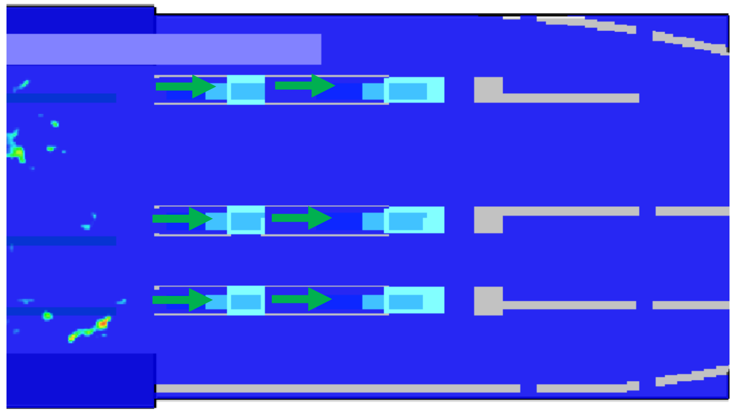
Fire Scenario 6 – T1-W 4 MW with 50% exhaust	
Britomart West Concourse (B1) 	Plan view at 2.0 m above B1 floor level: 846 seconds 
Glasshouse 	Plan view at 2.0 m above Glasshouse floor level: 846 seconds 

Fire Scenario 6 – T1-W 4 MW with 50% exhaust

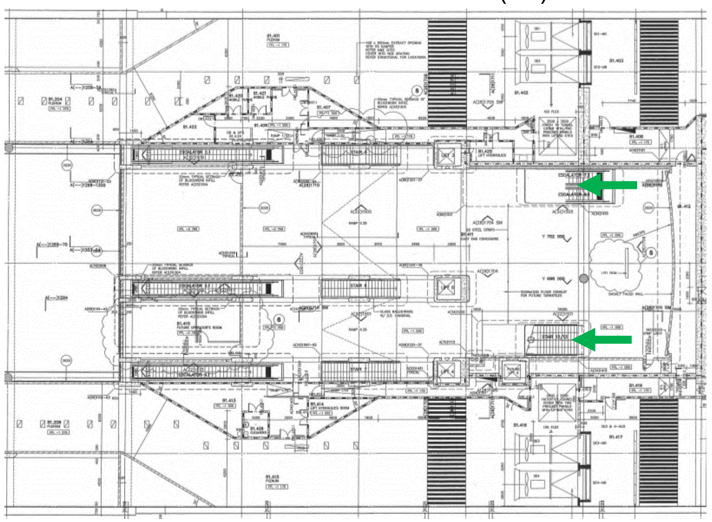
Britomart East Platform



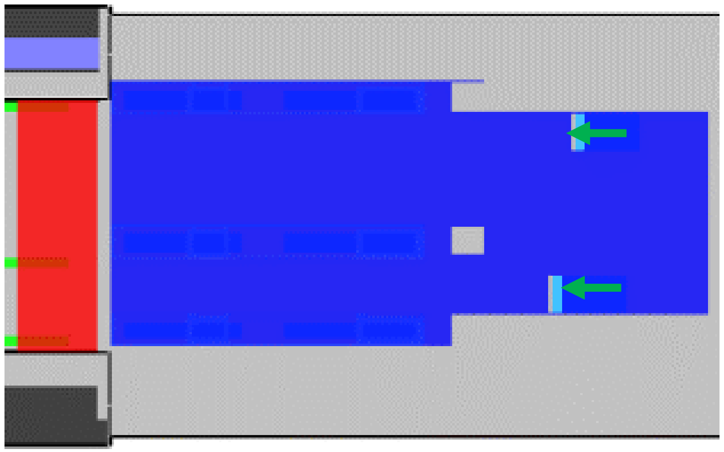
Plan view at 2.0 m above Platform floor level: 846 seconds



Britomart East Concourse (B1)

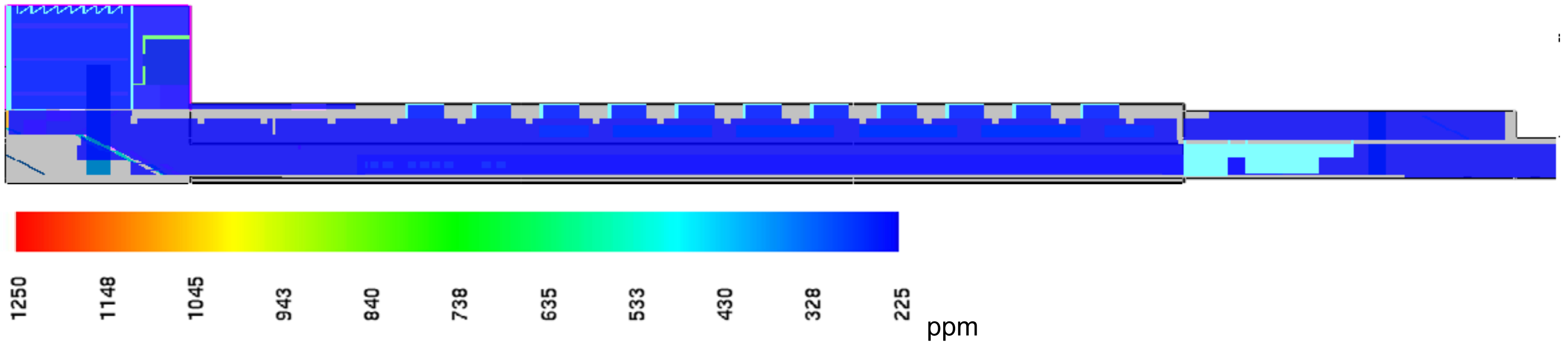


Plan view at 2.0 m above B1 floor level: 846 seconds



Fire Scenario 6 – T1-W 4 MW with 50% exhaust

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (846 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (14 minutes)

$FED_{CO} = (\varphi_{CO}/35{,}000)*\Delta t$

$FED_{CO} = (225/35{,}000)*14$

$= 0.090$ ($\leq$ 0.3 acceptable).

Fire Scenario 6 – T1-W 4 MW with 50% exhaust

$FED_{Thermal}$

Tenability limit for $FED_{Thermal}$ is exceeded when the $FED_{Thermal}$ is greater than 0.3

$FED_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

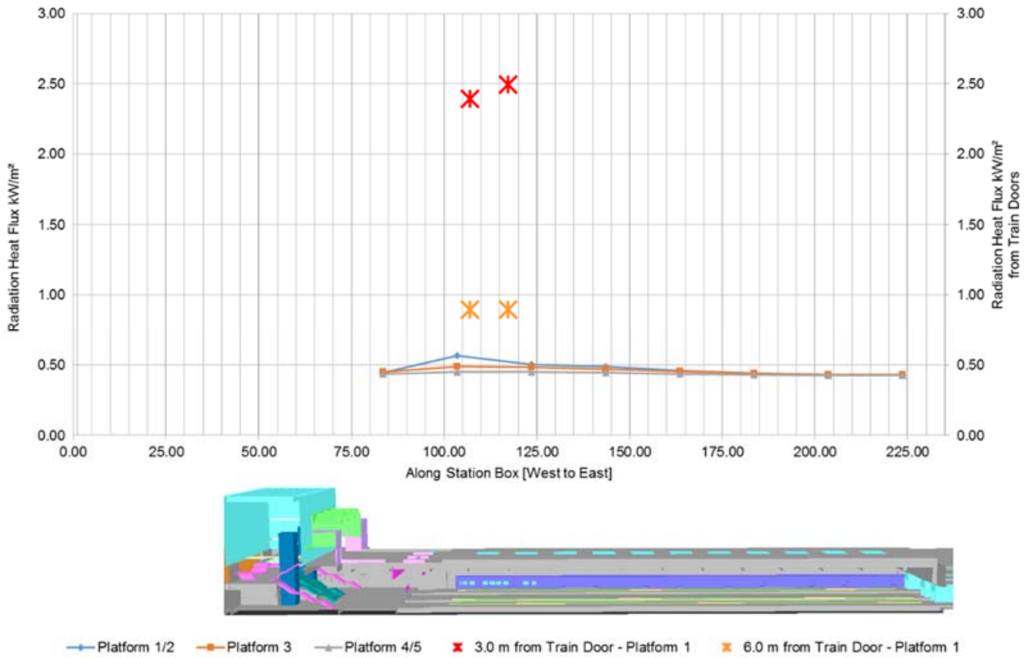
<u>Radiant Heat</u>

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (846 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

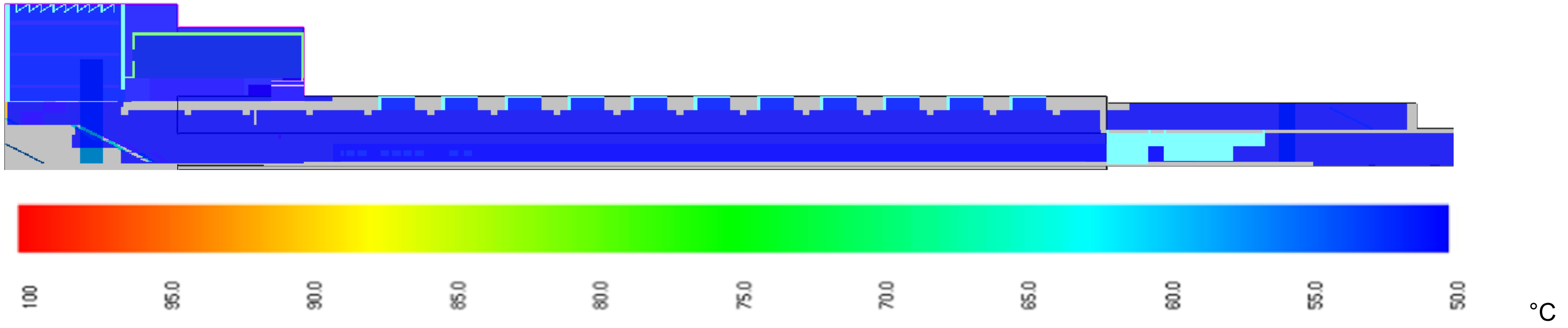
Therefore radiant heat can be discounted in the in $FED_{Thermal}$ calculation.

Radiant heat flux was also measure in front of the open train doors. Occupants can evacuate past the carriage of fire origin along the platform at least 3.0 m from the train door, where they are exposed to a maximum of 2.5 kW/m². Onset of pain occurs after being exposed for $t_p = (35/\dot{q}''_r)^{1.33} = (35/2.5)^{1.33} = 33$ seconds. Occupants will pass the exposure from the train door in a matter of seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 6 – T1-W 4 MW with 50% exhaust

Convective Heat



At 2.0 m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (846 seconds / 14 minutes)

$FED_{Thermal} = (1/t_{lconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*14$

$= 0.045$ (≤ 0.3 acceptable)

Fire Scenario 7 – T1-W 4 MW with no smoke curtains

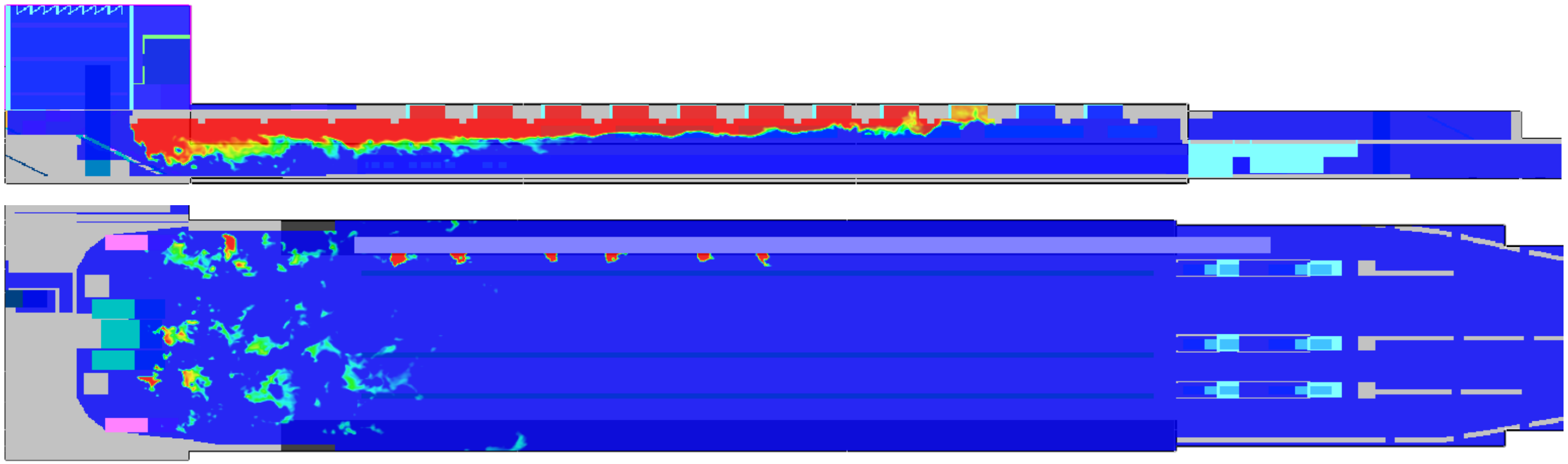
Visibility

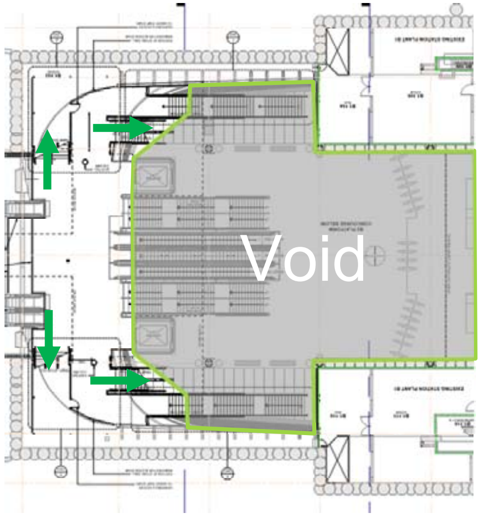
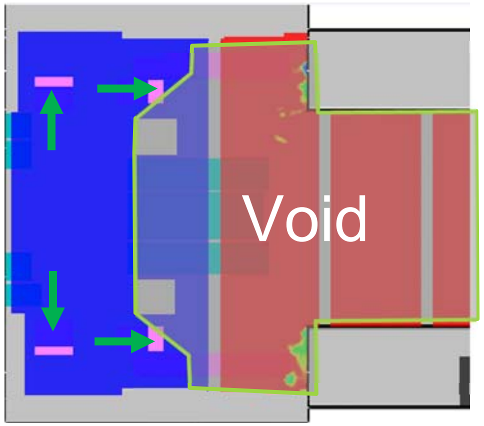
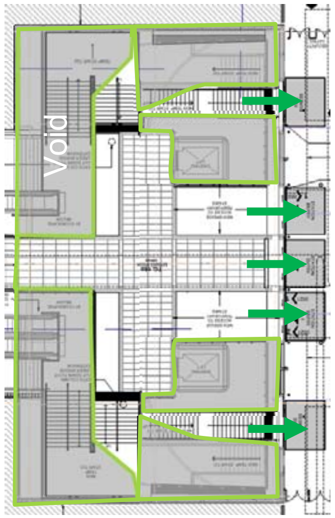
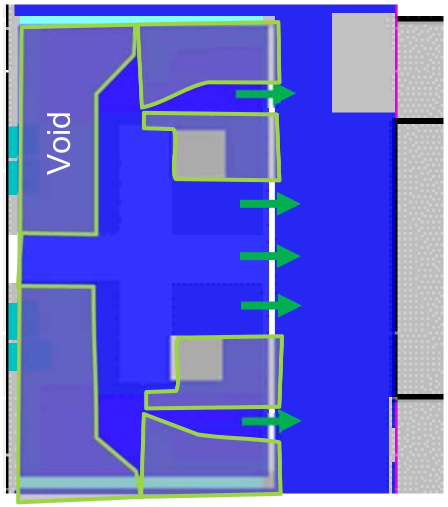
Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (1660 s).

In this fire scenario the tenability is considered to be maintained for > 660 seconds.

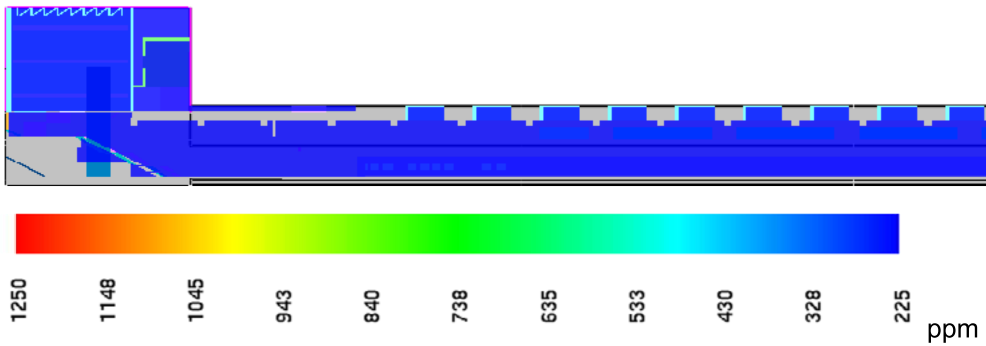
Platform Level



Fire Scenario 7 – T1-W 4 MW with no smoke curtains	
Britomart West Concourse (B1) 	Plan view at 2.0 m above B1 floor level 
Glasshouse 	Plan view at 2.0 m above Glasshouse floor level 

Fire Scenario 7 – T1-W 4 MW with no smoke curtains

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (660 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (11 minutes)

FED_{CO} = $(\varphi_{CO}/35{,}000)*\Delta t$

FED_{CO} = (225/35,000)*11

= 0.071 ($\leq$ 0.3 acceptable).

Fire Scenario 7 – T1-W 4 MW with no smoke curtains

$FED_{Thermal}$

Tenability limit for $FED_{Thermal}$ is exceeded when the $FED_{Thermal}$ is greater than 0.3

$FED_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

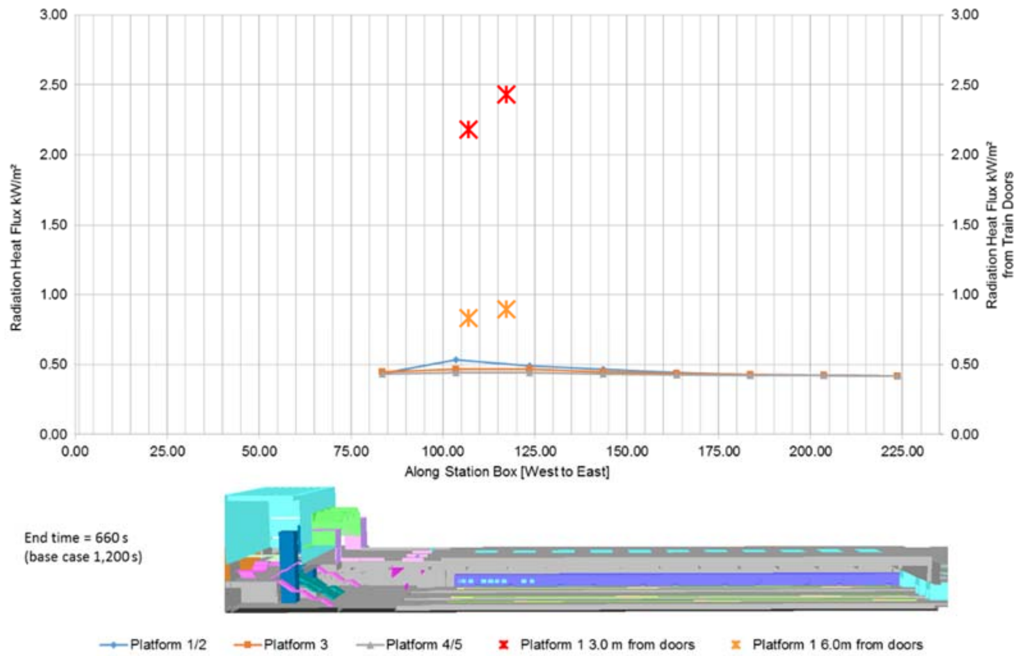
Radiant Heat

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (660 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

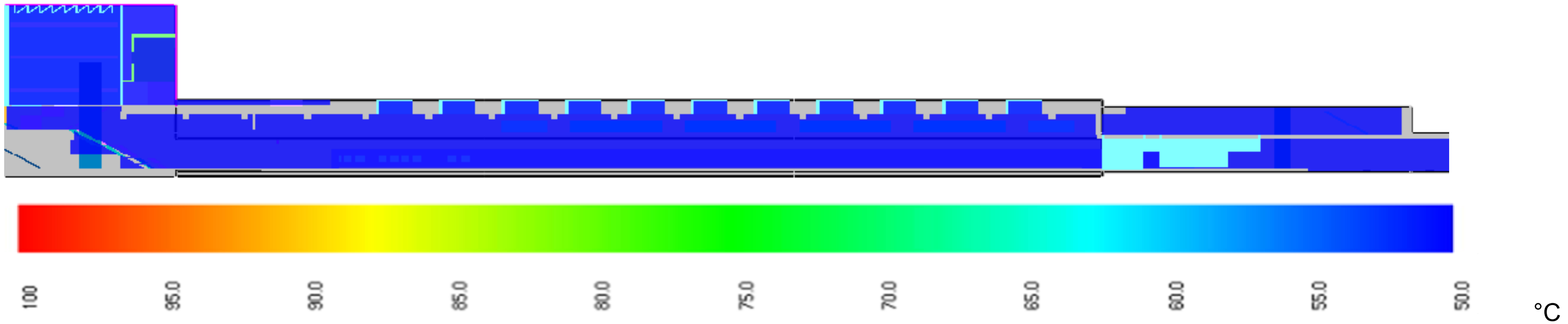
Therefore radiant heat can be discounted in the in $FED_{Thermal}$ calculation.

Radiant heat flux was also measure in front of the open train doors. Occupants can evacuate past the carriage of fire origin along the platform at least 3.0 m from the train door, where they are exposed to a maximum of 2.4 kW/m². Onset of pain occurs after being exposed for $t_p = (35/\dot{q}''_r)^{1.33} = (35/2.4)^{1.33} = 35$ seconds. Occupants will pass the exposure from the train door in a matter of seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 7 – T1-W 4 MW with no smoke curtains

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (660 seconds / 11 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*11$

$= 0.035$ ($\leq$ 0.3 acceptable)

Required Safe Egress Time

The Required Safe Egress Time (RSET) can be expressed in the following equation:

RSET = (t_d + t_n + t_{pre}) + (t_{trav} or t_{flow})

Each of these components are individually discussed and assessed below.

Alarm Time (t_d + t_n) and Pre-movement Time

As shown in the timeline of events, occupants are notified of a fire and begin moving within 60 seconds of the train reaching the platform.

In these scenarios the fire starts and is detected while the train is in the tunnel on approach to the station, therefore the station will be forewarned of a fire event and have the opportunity to begin station evacuation prior to the train entering the station. Furthermore, as occupants within the carriage of fire origin will begin evacuating immediately on station arrival, and other occupants on the train will naturally be egressing the station. Occupants waiting on the platform near the fire carriage will be clearly prompted by visual and olfactory cues as well as by evacuating occupants.

In the event the fire starts when the train is at the station or it is not detected until it reaches the station then the fire size will be much smaller than modelled in the fire scenarios, therefore improving the Available Safe Egress Time.

For the assessment the alarm time and pre-movement time have been taken to be from when the train comes to a stop within the station and is estimated to be:

Alarm Time and Pre-movement Time – 60 seconds

Travel Time (t_{trav} or t_{flow})

Evacuation times from the station will be assessed by spreadsheet calculation based on the methodology, travel speeds, and flow parameters promulgated by NFPA 130.

The travel time is the time required for occupants to reach a place of safety after starting evacuation. For Britomart station, the travel time utilises both the walking time to the exits/pinch points (walking time) and the queuing time around the exits/ pinch points (queuing time) to calculate the total time to travel to the exits.

- If the time required for the furthest occupant to reach the exit is greater than the time for queuing at the exit, then when that occupant reaches the exit he/she will pass straight through.
- However, when there are a large number of occupants in the space, the time to pass through the exit will usually be dominated by the queuing at the exit component rather than the time to walk to and reach the exit component.

Walking time will be determined by the formula below:

Walking time = Travel distance / walking speed

Queuing time is the time for occupants waiting in front of one exit/ pinch point to pass through the exit/ pinch point which is determined by the number of population, width of exits and flow rate through exits. This can be expressed by the equation below:

Queuing time = Population / (Exit width × Specific flow rate)

Table 4: Egress calculation parameters

Parameter		NFPA130 2015
Platforms, corridors, and ramps of 4% slope or less:		
Walking speed (platform)	m/min	37.7
Walking speed (concourse)	m/min	61
Flow	p/m.min	81.9
Stairs and ramps of over 4% slope - "up" direction:		
Walking speed (along slope)	m/min	14.6
Flow	p/m.min	55.5
Escalators (from project design data & tread size):		
Britomart Audit	p/min	75
Walking speed (vertical)	m/min	14.6
Stopped flow (walking upwards)	p/m.min	55.5
Doors		
Flow	p/m.min	81.9
Flow through single leaf door	p/min	60
Ticket Barriers		
Clear opening of 500 mm	p/min.gate	50
Emergency gates designed as single leaf doors	p/min.gate	60

Notes:

(1) The use of escalators for emergency passenger egress is addressed in Request for Building Code Waiver – NZBC Clause D1.3.3, and is consistent with the existing egress strategy within Britomart Station

(2) A delay to stop an escalator will not be considered in the egress calculation, as on activation of fire alarm system, the escalators will be automatically slowed to stop, which occurs during the nominated pre-movement period.

(3) An escalator is assumed to be out of service under different fire scenarios as per NFPA 130.

The total population within the station is taken to be 2,600 persons and the population has been divided in line with the Stacey Agnew assessment, which is proportional with respect to area of the platforms. As such:

- Platform 1/2 933 occupants
- Platform 3 736 occupants
- Platform 4/5 933 occupants

The nodes of the evacuation calculation are the exits/ pinch points and are outlined below:

From Britomart East (no change during Temporary Works).

Basement 2 to Basement 1

			Width (m)		Capacity [p/min]
		Platform 1/2			
	down	Esc 2.1	1.30		72.4
		Stair 5	1.50		83.3
		Sub Total	**2.80**	C_{E1A}	**155.6**
		Platform 3			
	down	Esc 3.1	1.30		72.4
		Stair 6	1.50		83.3
		Sub Total	**2.80**	C_{E1B}	**155.6**
		Platform 4/5			
	down	Esc 4.1	1.30		72.4
		Stair 7	1.50		83.3
		Sub Total	**2.80**	C_{E1C}	**155.6**

Basement 1 to Ground

			Width (m)			Capacity [p/min]
Gateline	*Fare barrier*		*0.50*	no.	8	400.0
	Emergency gate		*1.64*			134.6
					C_{E2}	**534.6**
	down	Esc 7.1	1.50			75.0
	up	Esc 8.1	1.50			75.0
		Stair 12/13	2.80			155.4
		Total	**5.80**		C_{E3}	**305.4**

Similarly for Britomart West

		Width (m)			Capacity [p/min]
West End Fare Gates					
	Fare barrier	*0.50*	no.	13	650
	Accessible gate	*1.00*	no.	2	120
	Emergency gate	*1.72*			141
				C_{W1}	**910.9**

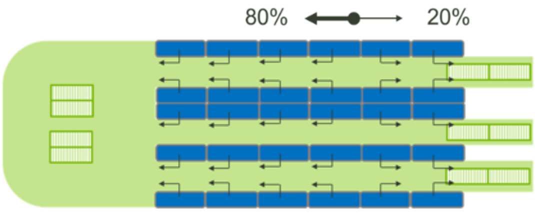
West End Basement 2 to Basement 1

		Width (m)		Capacity [p/min]
	New Temp Stair T21	1.70		94.4
	Exisiting Stair 2	2.90		161.0
up	Esc 1.3	1.00		75.0
down	Esc 1.2	1.00		55.5
OUT	Esc 1.1	1.00		0.0
	Existing Stair 1	2.90		161.0
	New Temp Stair T20	1.70		94.4
	Total	**12.20**	C_{W2}	**641.1**

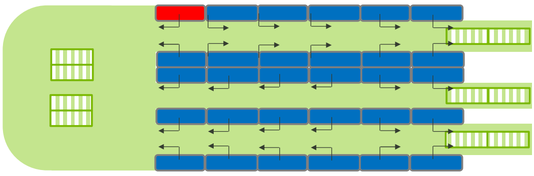
A number of egress scenarios have been considered. As a base case, the population is split proportionally with respect to available egress width. So, from each platform the occupant population evacuates 80 % to the West and 20 % to the East.

There are then fire scenario specific cases which consider where occupants can/will not evacuate past the carriage of fire origin. So, on the fire platform occupants evacuate one carriage to the fire affected end and five carriages to the non-fire affected end, i.e. 17% to 83% split.

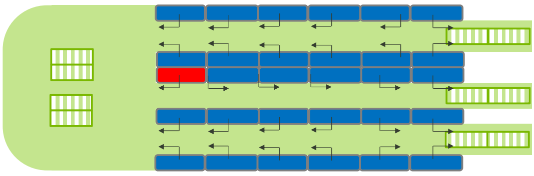
As illustrated below:



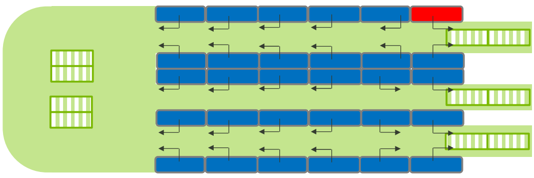
Case 1: Base Case



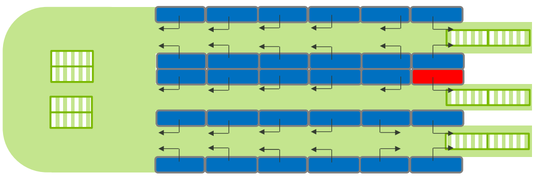
Case 2: T1 west



Case 3: T3 west



Case 4: T1 east



Case 5: T3 east

The egress calculation considers the time to clear the platform and the time to clear the station onto street level. However, it is noted that once occupants have cleared the Platform at Britomart East they are effectively separated from the effects of fire. There are enclosures around the stairs/ escalators and make-up air being drawn down through the stair/escalator openings, which effectively keeps the escape route clear of smoke in a fire event.

From Britomart West, as the concourse and Glasshouse are open to the station below, time to clear the station has also been calculated.

The clearance times are summarised below

Case	Exit Path Blocked by Fire	East/West Split			Clearance Time [seconds]			
		P1/2	P3	P4/5	Platform East	Station East	Platform West	Station West
1	None	20:80	20:80	20:80	72[JA2]	258	239	498
2	T1 west	83:17	20:80	20:80	300	458	239	478
3	T3 west	20:80	83:17	20:80	236	395	239	478
4	T1 east	17:83	21:79	20:80	72*	252	247	515
5	T3 east	20:80	17:83	20:80	72*	254	247	507

* *It is expected that the occupants within immediate proximity of the fire will begin evacuating immediately without an alarm time or pre-movement time, therefore in the event of a fire in Carriage 6 the time to clear the platform closest to the fire via the Britomart East exits is:*

- *Platform 1/2 in 60 seconds/72 seconds (Case4/Case 5 respectively).*
- *Platform 3 in 57 seconds/48 seconds (Case4/Case 5 respectively).*

A full worked example for the base case is contained within Appendix K.

RSET

The RSET from each end of Britomart Station includes an ***additional 60 seconds*** of Alarm Time and Pre-movement Time as composited here:

Case	Exit Path Blocked by Fire	East/West Split			Clearance Time [seconds] (***1.5 x RSET***)			
		P1/2	P3	P4/5	Platform East	Station East	Platform West	Station West
1	none	20:80	20:80	20:80	132 *198*	318 *477*	299 *448*	558 *837*
2	T1 west	83:17	20:80	20:80	360 *540*	518 *778*	299 *448*	538 *807*
3	T3 west	20:80	83:17	20:80	296 *445*	455 *683*	299 *448*	538 *807*
4	T1 east*	17:83	21:79	20:80	132 *198*	312 *468*	307 *461*	575 *863*
5	T3 east*	20:80	17:83	20:80	132 *198*	314 *470*	307 *461*	567 *851*

* *It is expected that the occupants within immediate proximity of the fire will begin evacuating immediately without an alarm time or pre-movement time, therefore in the event of a fire in Carriage 6 the time to clear the platform closest to the fire via the Britomart East exits is:*

- *Platform 1/2 in 60 seconds/72 seconds (Case4/Case 5 respectively).*
- *Platform 3 in 57 seconds/48 seconds (Case4/Case 5 respectively).*

ASET vs RSET Summary

Base case fire scenarios will be compared against both the base case egress scenarios 1.5 x Case 1, and the relevant sensitivity case.

Fire Scenario		Egress scenario	ASET vs RSET (*1.5 x RSET*)				ASET ≥ RSET	Comments
			Platform East	Station East	Platform West	Station West		
1	Base Case - T1C1 4MW	1.5xCase 1	*1200 vs 198*	*1200 vs 477*	*1200 vs 448*	*1200 vs 837*	*Yes*	
		Case 2	360	518	299	538		
2	Base Case - T3C1 4MW	1.5xCase 1	*1200 vs 198*	*1200 vs 477*	*1200 vs 448*	*1200 vs 837*	*Yes*	
		Case 3	296	455	299	538		
3	Base Case - T1C6 4MW	1.5xCase 1	*1200 vs 198*	*1200 vs 477*	*1200 vs 448*	*1200 vs 837*	*Yes*	Tenability maintained for duration of model, except Britomart East Platform 1/2 due to the fire location being directly beside the exits. It is expected that the occupants within immediate proximity of the Britomart East exits on platform 1/2 including occupants in Carriage 6 will utilise the Britomart East exits during the growth phase of the fire. This is in line with Egress Case 4, which calculates the clearance time of Platform 1/2 at Britomart East to be 60[JA3] seconds. It is expected that in the immediate vicinity of the fire, occupants will begin evacuating immediately i.e. no alarm or pre-movement time.
		Case 4	132	312	307	575		
4	Base Case - T3C6 4MW	1.5xCase 1	*1200 vs 198*	*1200 vs 477*	*1200 vs 448*	*1200 vs 837*	*Yes*	Tenability maintained for duration of model, except Britomart East Platform 3 due to the fire location being directly beside the exits. It is expected that the occupants within immediate proximity of the Britomart East exits on platform 3 including occupants in Carriage 6 will utilise the Britomart East exits during the growth phase of the fire. This is in line with Egress Case 5, which calculates the clearance time of Platform 3 at Britomart East to be 48 seconds. It is expected that in the immediate vicinity of the fire occupants will begin evacuating immediately i.e. no alarm or pre-movement time.
		Case 5	132	314	307	567	Yes	

Fire Scenario		**Egress scenario**	**ASET vs RSET (*1.5 x RSET*)**				**ASET ≥ RSET**	**Comments**
			Platform East	**Station East**	**Platform West**	**Station West**		
5	Sensitivity - T1C1 10 MW	Case 1	*1200* *vs* 132	*1200* *vs* 318	720 *vs* 299	*1200* *vs* 558	*Yes*	
		Case 2	360	518	299	538	Yes	
6	Redundancy T1C1 50%	Case 1	*846* *vs* 132	*846* *vs* 318	588 *vs* 299	318 *vs* 558	*East Yes West No**	Based on the RSET occupants evacuating via Britomart West are expected to have cleared the platform and either be within the concourse/GH when tenability criteria in these areas are exceeded or have completed evacuation. Occupants are expected to continue evacuating in reduced visibility conditions as the egress route is intuitive (only one direction possible) and they are heading towards outside ('daylight'). As noted in the ASET assessment, occupants will continue to travel in lower visibilities, however reduce their speed down to visibilities of approximately 3 m. As shown in the results at the conclusion of the simulation (846 seconds) visibility within the egress paths is still generally about 4 m. Furthermore, if occupants within the station observe deteriorating conditions within the concourse and decide not to proceed they are able to evacuate via Britomart East with tenable conditions provided indefinitely.
		Case 2	360	518	299	538		
7	Redundancy T1C1 no SC	Case 1	*660* *vs* 132	*660* *vs* 318	*660* *vs* 299	*660* *vs* 558	*Yes*	
		Case 2	360	518	299	538		

In the event the RSET exceeds the ASET at a given exit, if tenability is maintained for the duration of the model (indefinitely) along alternate egress paths, occupants are able to travel away from the effects of fire and egress toward the other end of the station. Staff are to be trained to supervise evacuations and can direct occupants to the most appropriate exit in any give fire scenario.

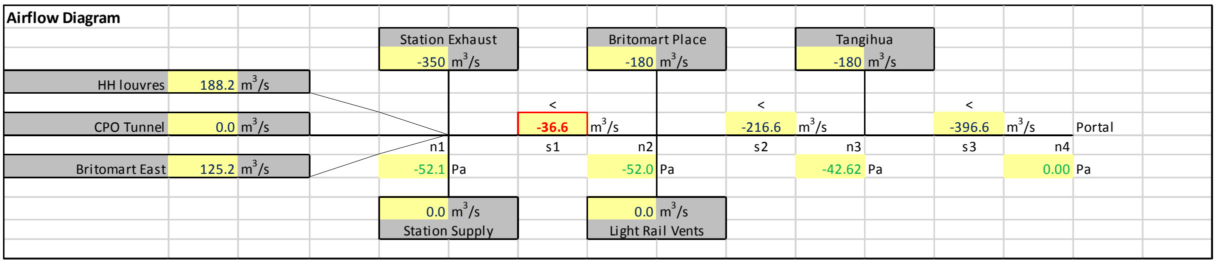
Option Retain Existing Ventilation Mode During Temporary Works

During detailed design it was proposed that the existing response modes be maintained throughout the Temporary Works. The 1D flow modelling for both the modelled case and the existing ventilation strategy are compared below.

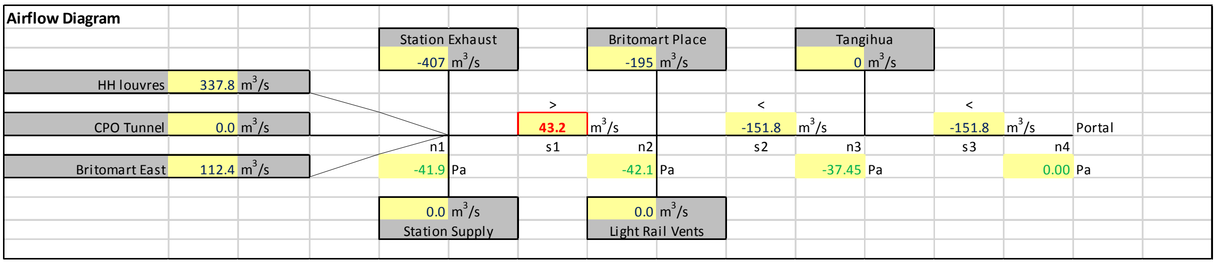
Table 53: SCADA Response Modes modelled and the existing which is proposed to be retained

Stage	Ventilation Strategy	Station Supply Fans	Station Transfer Fans	Station Exhaust Fans	Britomart Place	West Tunnel Jet Fans	Tangihua Street Exhaust Fans	East Tunnel Jet Fans
Modelled	Fire at Station Platforms	Off	Off	Exhaust 350 m^3/s	Exhaust 180 m^3/s	Off	Exhaust 180 m^3/s	Off
Existing	Fire at Station Platforms	Off	Off	Exhaust 407 m^3/s	Exhaust 195 m^3/s	2 fans to east	Off	Off

Proposed Ventilation Condition as Modelled (Glasshouse 50% Open)



Existing / Current Ventilation Condition (Glasshouse 100% Open)

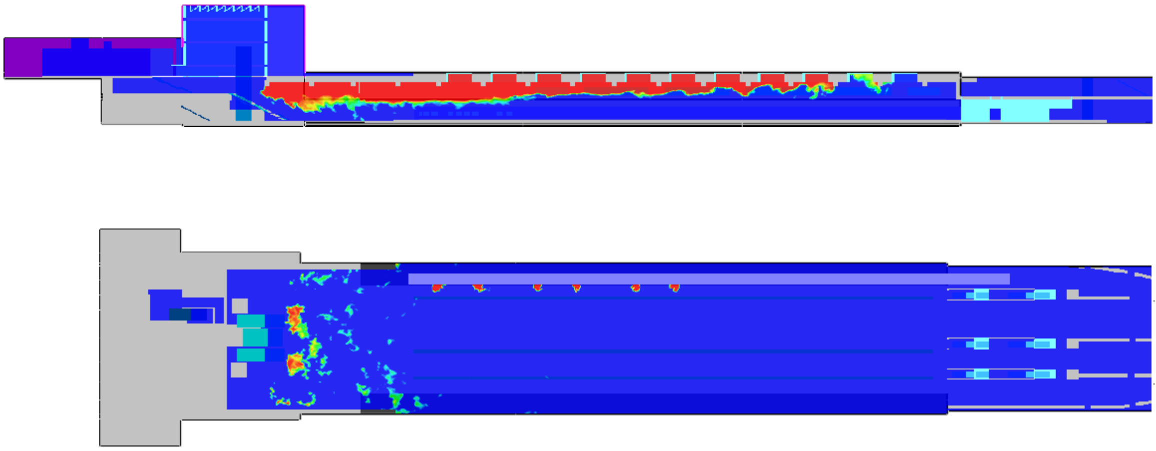
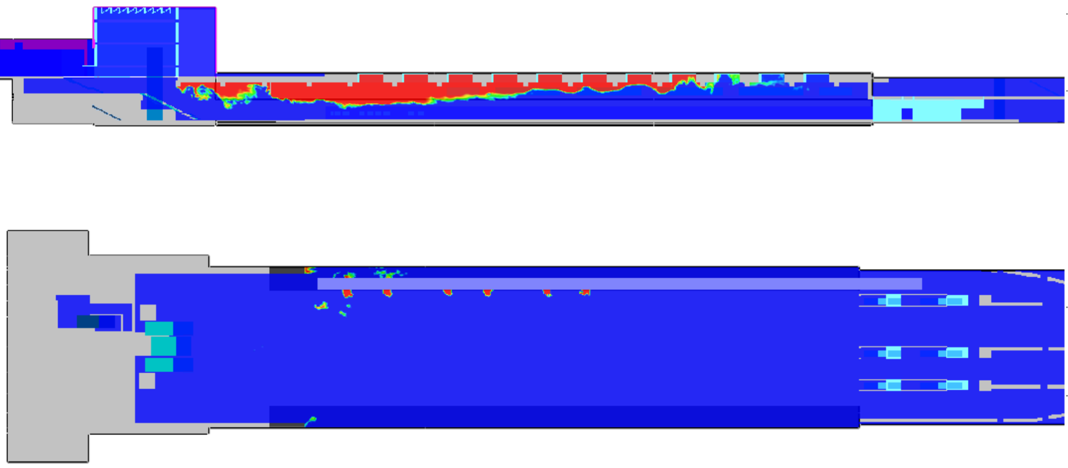


Validation of the existing ventilation response modes has been addressed by comparing the worst case Base Case fire models, with a fire located at each end of Britomart Station:

Fire Scenario		Fire Location
1E	Base Case	T1-W
3E	Base Case	T1-E

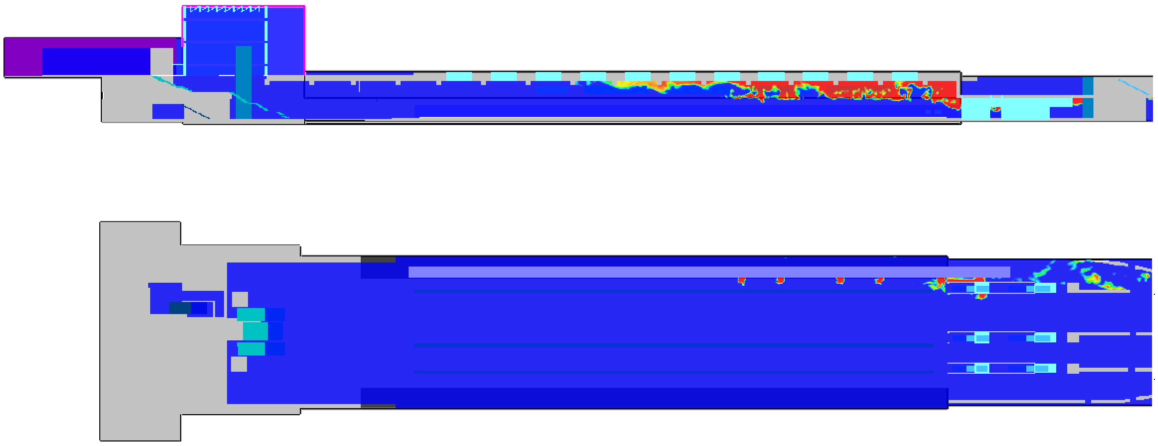
The comparison of the modelling results, shown below, demonstrate the existing ventilation conditions provides sufficient agreement with the modelling to demonstrate comparable performance without re-running the full suite of models. It is noted that when the fire is located at the east end of the station conditions at the east end are less tenable compared to the existing modelling due to a net air flow to the east. This is not considered unduly detrimental due to the majority of occupants evacuating to the west. Based on the comparison the existing ventilation strategy may be maintained for a Britomart Station Fire for the Temporary Works stage.

Visibility [m]

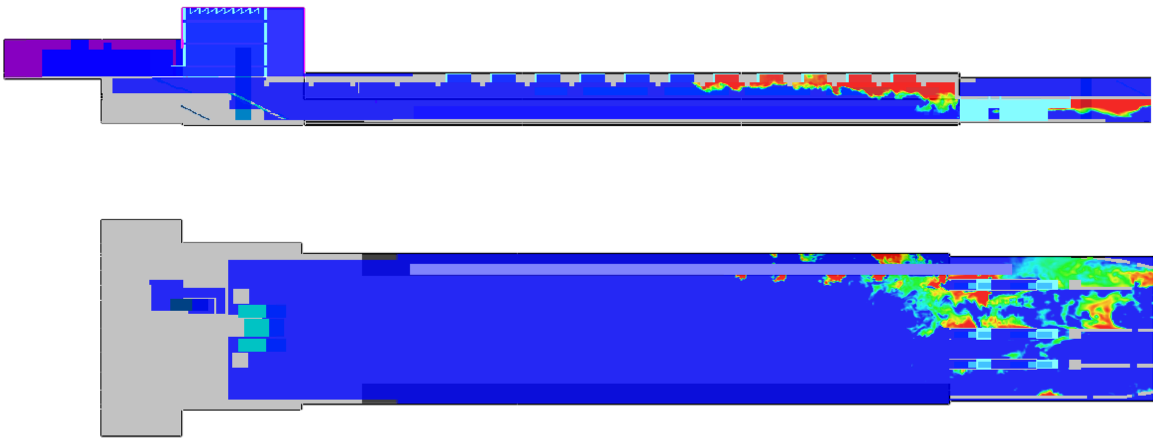
T1-West End 4 MW @ 1,200 seconds
Temporary Works Proposed Ventilation Condition 
Existing Ventilation Condition 

T1-East End 4 MW @ ~1,000 seconds

Temporary Works Proposed Ventilation Condition



Existing Ventilation Condition



Modelling of the Existing / Current Ventilation condition considered the glasshouse louvres to be 100% open. In assessing airflows under comparable glasshouse disposition yields the following airflow splits that are roughly equivalent to those results from the proposed configuration. As such, it can be reasonably assumed that the conditions will be similar to those presented in preceding sections.

Existing / Current Ventilation Condition (Glasshouse 50% Open)

Airflow Diagram													
			Station Exhaust			Britomart Place			Tangihua				
			-407	m³/s		-195	m³/s		0	m³/s			
HH louvres	208.3	m³/s											
					<			<			<		
CPO Tunnel	0.0	m³/s			-60.1	m³/s		-255.1	m³/s		-255.1	m³/s	Portal
			n1		s1	n2		s2	n3		s3	n4	
Britomart East	138.6	m³/s	-63.8	Pa		-63.6	Pa		-50.58	Pa		0.00	Pa
			0.0	m³/s		0.0	m³/s						
			Station Supply			Light Rail Vents							

System Failures

This assessment of system failures has considered the following system failure scenarios.

System	Description	Assessment	Comment
Smoke Management	Reliance on any mechanical or electrical component for activation	Quantitative	Refer Fire Scenario 6 and Fire Scenario 7
Fire Closures	Fire and/or smoke control doors or similar fire closures. Where installed and maintained in accordance with NZ or international standard the system is considered sufficiently reliable.	Qualitative	BOH and FOH are fire separated. There are no hold open devices between these areas and due to security requirements to keep the public out of BOH areas these doors will be constantly monitored to ensure fire doors are closed
Fire sprinkler system	Fire sprinkler systems system failure is considered highly unlikely as supported by many assumptions in the NZBC C/AS documentation which permit numerous concessions where fire sprinkler systems are installed. FEDG notes that, in New Zealand, fire sprinkler systems have a very good reliability record.	N/A	Platforms, the Britomart West concourse, and Glasshouse are not fire sprinkler protected. BOH areas where fire sprinklers are installed will be installed and maintained in accordance to NZ Standards
Fire detection & alarm system	Automatic fire alarms installed to a recognised national or international Standard, can be considered to be sufficiently reliable. This is supported by many assumptions in the NZBC C/AS documentation including the allowance to increase the length of escape routes where fire and detection systems are installed.	Qualitative	Detection is only provided at high level above the station, BOH areas where there are no sprinklers, and linear heat detection at Glasshouse roof level. All systems are to be installed in accordance to NZ Standards. Further redundancy is provided by: The alternative means by which fire can be detected is as follows: • Visual detection by building occupants. • Visual detection by staff monitoring the CCTV • Automatic heat detection using the sprinklers as thermal detectors.

System	Description	Assessment	Comment
			The alternative means by which a fire alarm may be raised and evacuation initiated is as follows: • Staff / occupants. • Staff manually initiating the occupant warning system or making announcements over the PA system.
Exit Blocked	An escape route may be blocked due to proximity of the fire source	Qualitative	Multiple exits provided. Tenable conditions provided for greater than 1.5 x RSET allows additional time for occupant egress in the event an exit is blocked. Egress scenarios also consider an exit blocked by fire.

Fire Fighting Operations

In all fire scenarios the modelling demonstrated that along the platforms the radiant heat flux 1.5 m above floor level, at the end of the simulated time, is well under the 4.5 kW/m² limit required per Performance Requirement C3.8.

Furthermore, the modelling demonstrates that visibility is maintained above 10 m from at least the non-fire end of the platform for the duration of the model for all fire scenarios. Where visibility is greater than 10 m it can be reasonably assumed that that area is relatively smoke-free and beneath the smoke layer.

The modelled times are sufficient to encompass fire service response times, which according to the national service delivery guidelines (2015 Annual Report, NZFS Commission) aim to have a response time to structure fires of 8 minutes 90% of the time for career stations.

The two nearest fire stations are:

Fire Station	Address	Distance*
Auckland City Station	40 Pitt Street, Auckland, 1010	2.1 km
Ponsonby	182 Ponsonby Road, Ponsonby, 1011	3.0 km

* Route distance calculated by google maps ref. map data © 2015 Google

Our shortest simulation time is 660 seconds (11 minutes) for a redundancy case, however the base case fire scenarios (up to 20 minutes) show conditions have reached steady-state with suitable conditions for fire fighter intervention.

The NZFS can access the platforms from either end of the station and therefore can approach a train or platform fire event from the non-fire side. Modelling has demonstrated that acceptable conditions are maintained in line with the provisions outlined in NZBC C3.8.

Comparative Assessment

The previous consent documents (Stacey Agnew, Britomart Station Fire Life Safety Review 3586-R01, 26 August 2011) included modelling results of fire scenarios within the station under existing (pre-Enabling) conditions. As there were diesel trains in operation within the station, the design fire was a 52 MW ultra-fast fire (i.e., the peak HRR was achieved within 540 seconds). Stacey Agnew modelling considered fire scenarios at locations along track 3: T3-W, T3-E and T3 middle.

Our corresponding base cases, T3-W and T3-E, have been compared below to demonstrate that during the Temporary Works there is relative improvement of the conditions within Britomart Station in the event of and (EMU) train fire. The improvements are attributable in large part to the reduction in design fire due to the cessation of diesel train services prior to the onset of the Temporary Works.

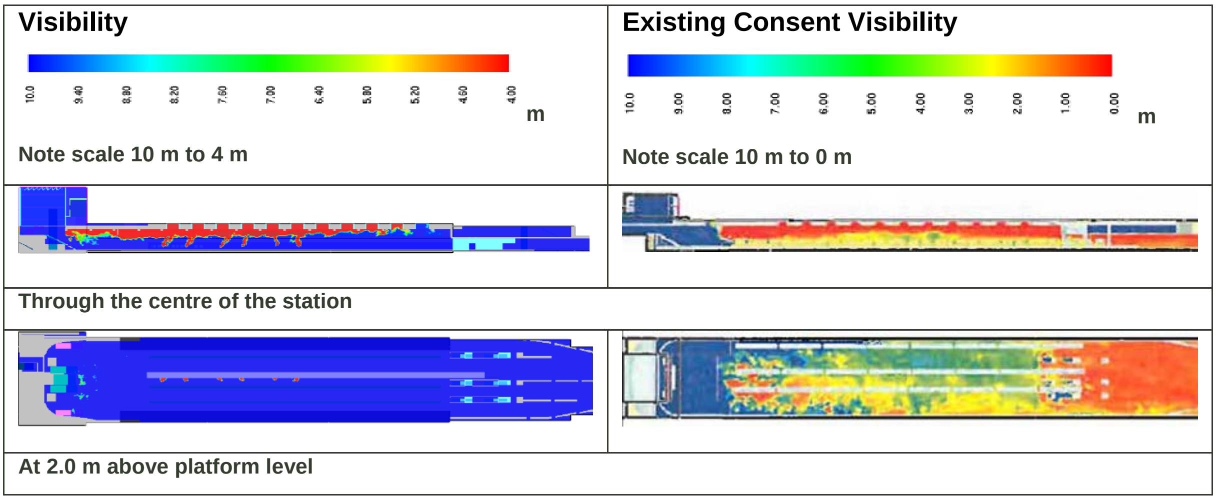


Figure 9: T = 600 s, Base Case train fire located T3 - W

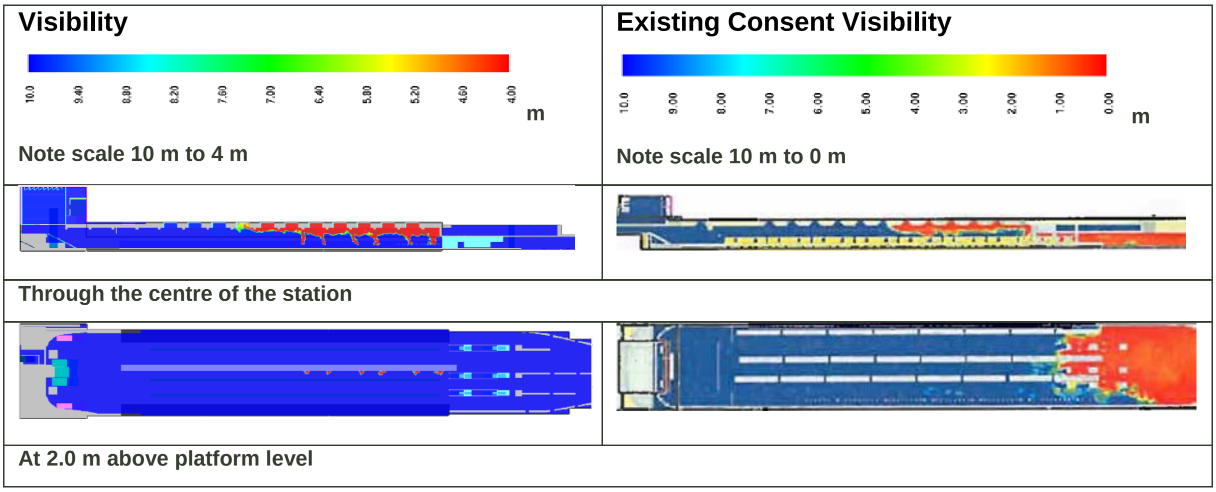


Figure 10: T = 600 s, Base Case train fire located T3 – E

Conclusions

Britomart Station under Temporary Works conditions satisfies the Performance Requirements C3.8, C3.9, C4.3 and C4.4 of the NZBC.

Appendix E
Post Enabling Works
Britomart Transport Centre
Assessment

Analysis

This section presents a quantitative timeline assessment of the Available Safe Egress Time (ASET) compared with the Required Safe Egress Time (RSET) for occupants within Britomart Station, also referred to as Britomart Transport Centre (BTC).

Britomart Station is assessed by specific fire engineering deisgn, and the results will be compared with results from Stacey Agnew who undertook the most recent modelling for the existing consent.

Britomart Station has been assessed in the Temporary Works State and the Permanent Works State. This section presents the results during the Permanent Works, which has many of the same inputs as during the Temporary Works phase, though the geometry is different.

Justifications and calculation methods are the same as those described for the Temporary Works.

Available Safe Egress Time

The ASET times have been calculated by undertaking CFD modelling of the interconnected parts of the building. The input times for various parts of these models are summarised below.

Design Fire and Fire Scenarios

The fire scenarios and design fires has been agreed within the design team and stakeholders as part of the FEB process.

Train fires have been considered the worst case scenarios. As discussed in the FEB DMU and diesel trains will not be operating within Britomart Station Permanent Works. The EMU fire scenarios are set out in a separate document, identifying Design Fire and Sensitivity Cases for CRL. The parameters of this scenarios are summarised below.

Table 1: Design Fire Parameters

Design Fire Parameters	Design Fire 1	Design Fire 2
Design Fire ID	Fast t^2 4MW	Medium t^2 10MW
Fire growth rate	Fast t^2 fire	Medium t^2 fire
HRR	Starts at 1.055 MW Peak 4 MW As calculated below	Starts at 0.380 MW Peak 10 MW As calculated below
Area	8 m x 2 m	20 m x 2 m
Comment	Train doors open Windows remain intact for duration of model	Train doors open Windows remain intact for duration of model

In a worst-case scenario, it is assumed that a train fire starts prior to the train entering the tunnel portal into Britomart Station, but is not detected until after the train has entered the portal. The size of the fire once the train enters the station is bound by the following assumptions due to operating procedures:

- if a fire is detected on the train prior to reaching the portal it will not proceed into the tunnels
- if a fire is detected on the train within the Britomart tunnels, it will proceed into the station.

The following train timeline events describe the Britomart Station Design Fires. These assumptions have been previously presented to, and agreed to by the project stakeholders.

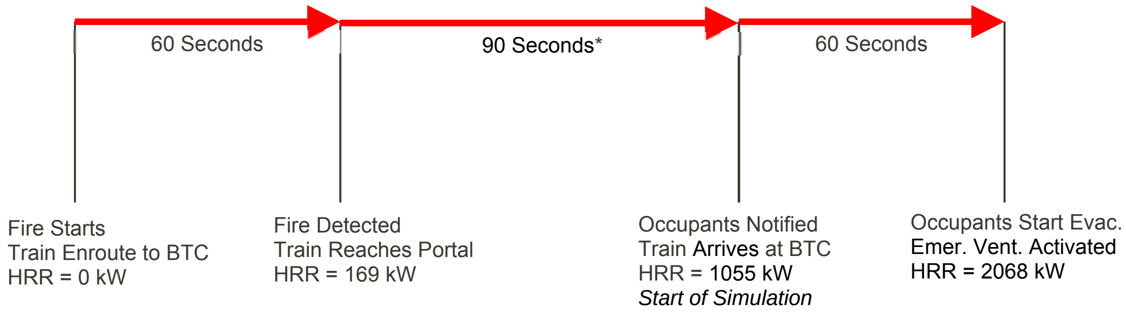


Figure 1: Timeline of Events Fast t² Train Fire

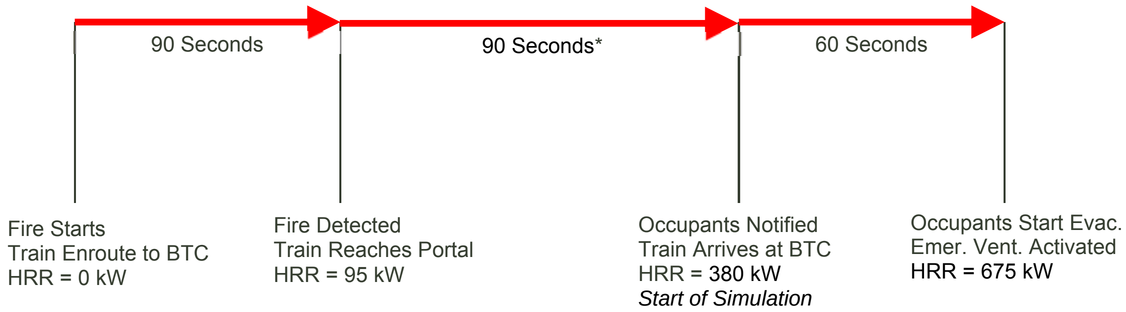


Figure 2: Timeline of Events Medium t² Train Fire

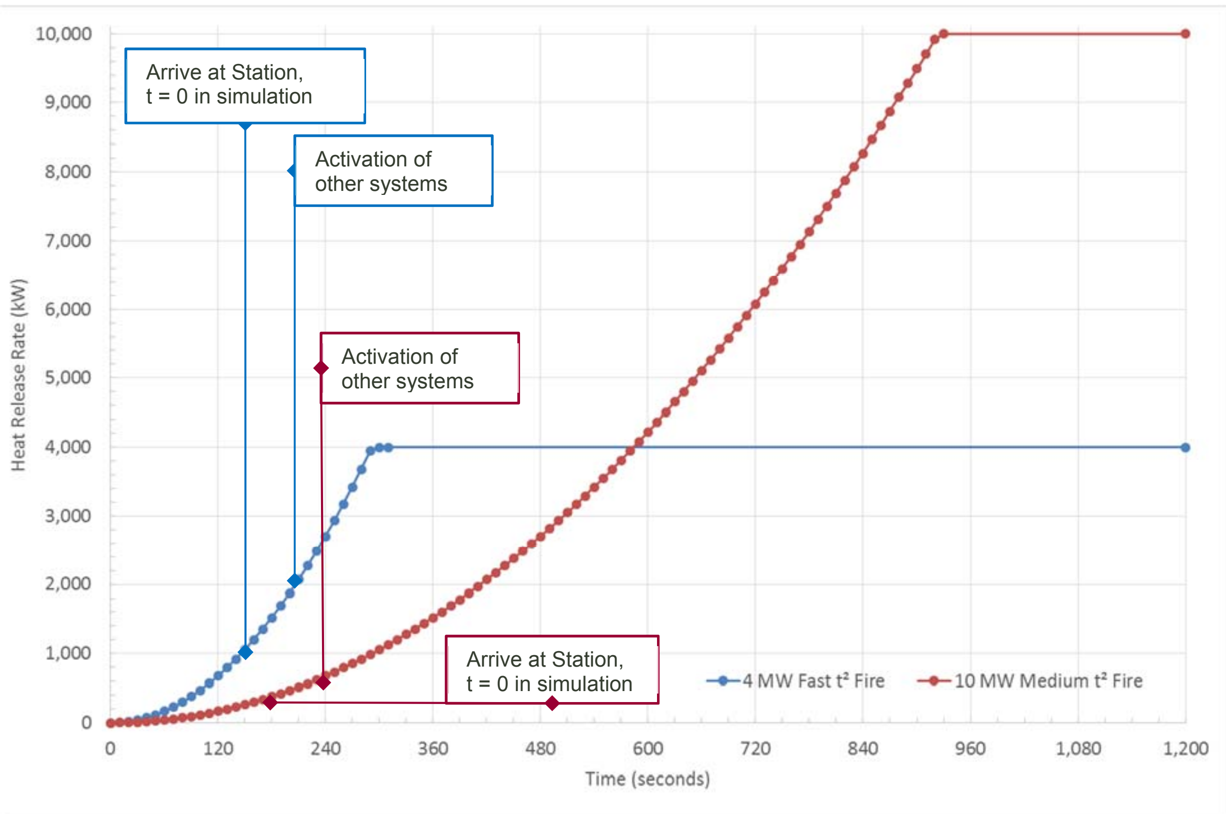


Figure 3: Britomart Station Train Design Fires

The following locations were investigated for the different fire scenarios:

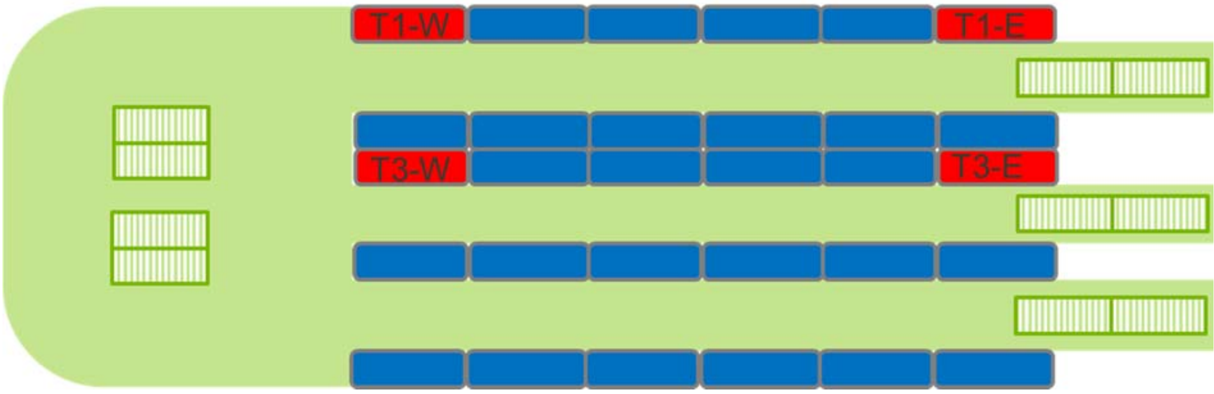


Figure 4: Britomart Station Fire Scenario Locations

Track 1: Examine smoke spread under plenum structure

Track 3: Examine smoke development/spread in high bay space

West end: Maximum potential threat to primary egress paths to west, stresses egress systems to east

East end: Stresses egress systems to west

The results from the Temporary Works fire scenarios were rationalised so that only the worst case base cases were modelled in the Permanent Works configuration. The worse performing cases were both located along Track 1 (e.g., T1-W and T1-E).

Table 2: Fire Scenarios

Fire Scenario	Location	Design Fire	Case	Comments
1P: T1-W	Track 1 Carriage 1	Fast t² 4 MW	Base Case	Fully function systems
~~2: T3-W~~	~~Track 3, Carriage 1~~	~~Fast t² 4 MW~~	~~Base Case~~	~~Fully function systems~~
3P: T1-E	Track 1, Carriage 6	Fast t² 4 MW	Base Case	Fully function systems
~~4: T3-E~~	~~Track 3, Carriage 6~~	~~Fast t² 4 MW~~	~~Base Case~~	~~Fully function systems~~
5P: T1-W	Track 1 Carriage 1	Medium t² 10 MW	Sensitivity	Fully function systems
6P: T1-W	Track 1 Carriage 1	Fast t² 4 MW	Redundancy	50 % Mechanical exhaust
7P: T1-W	Track 1 Carriage 1	Fast t² 4 MW	Redundancy	Smoke curtain failure

As determined in the Temporary Works simulations, the highest challenge fire location was Fire Scenario 1 (T1-W). As such, the sensitivity and redundancy cases were tested in the Track 1 – West (Carriage 1) location.

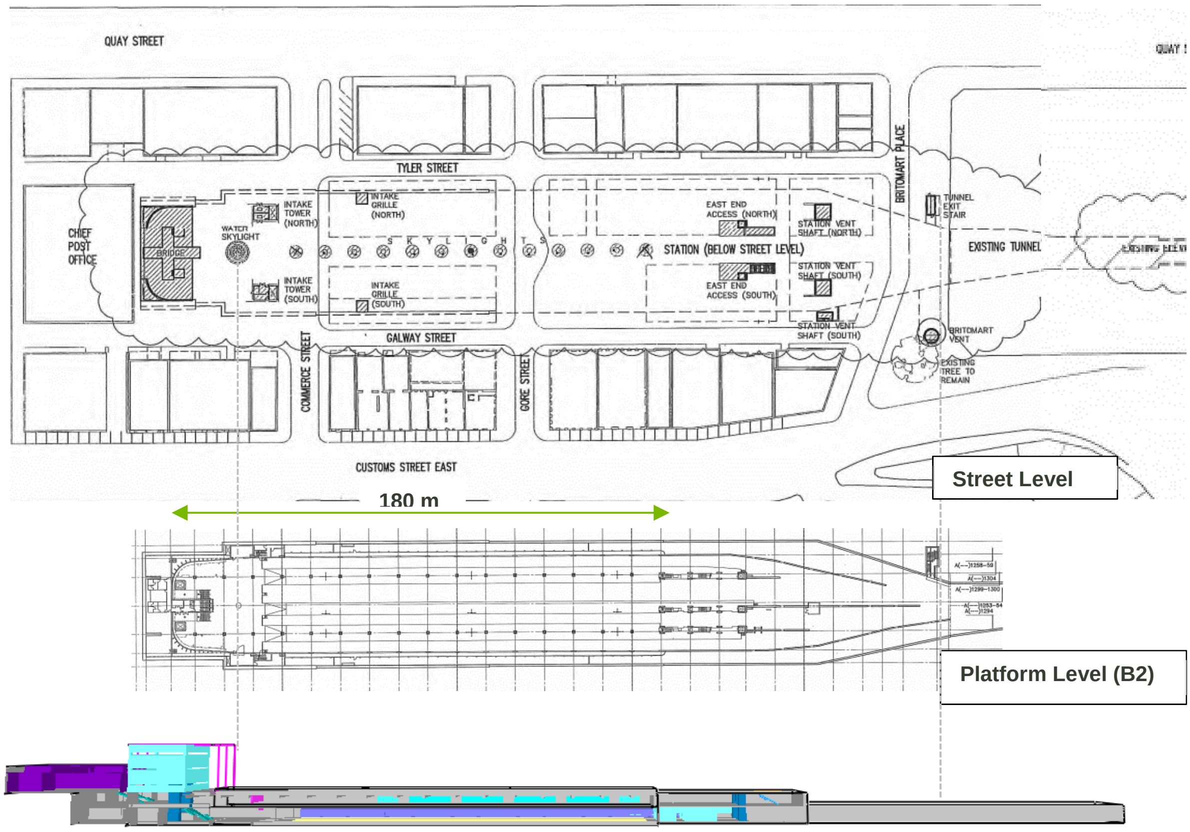


Figure 5: Britomart Station Overview –Plans and FDS model geometry

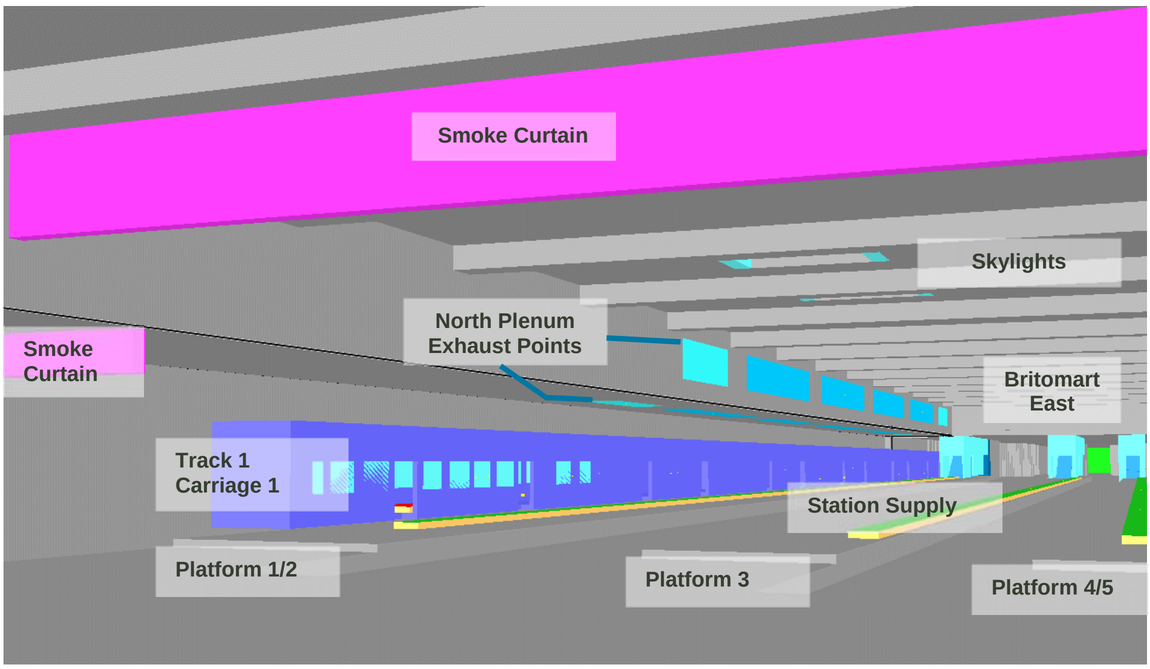


Figure 6: Britomart Station Platform – Internal View

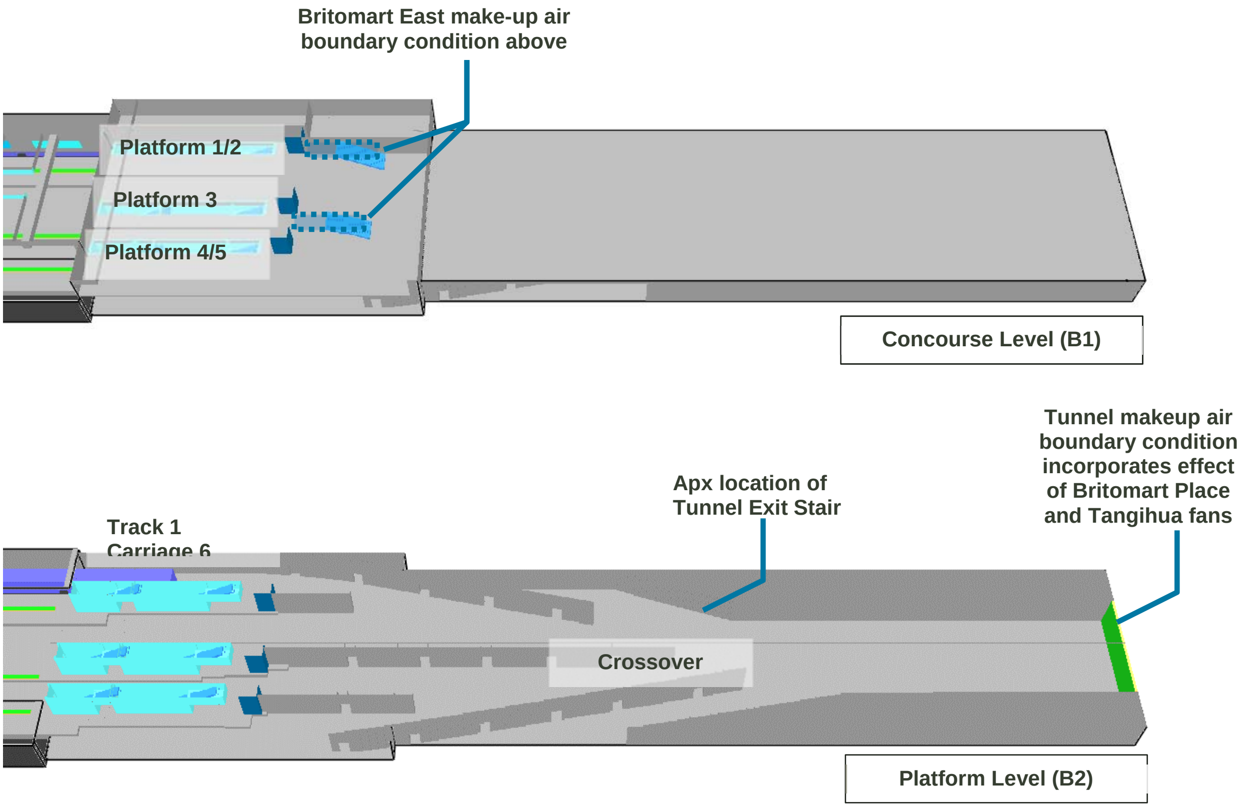


Figure 7: Britomart East and Tunnel Crossover

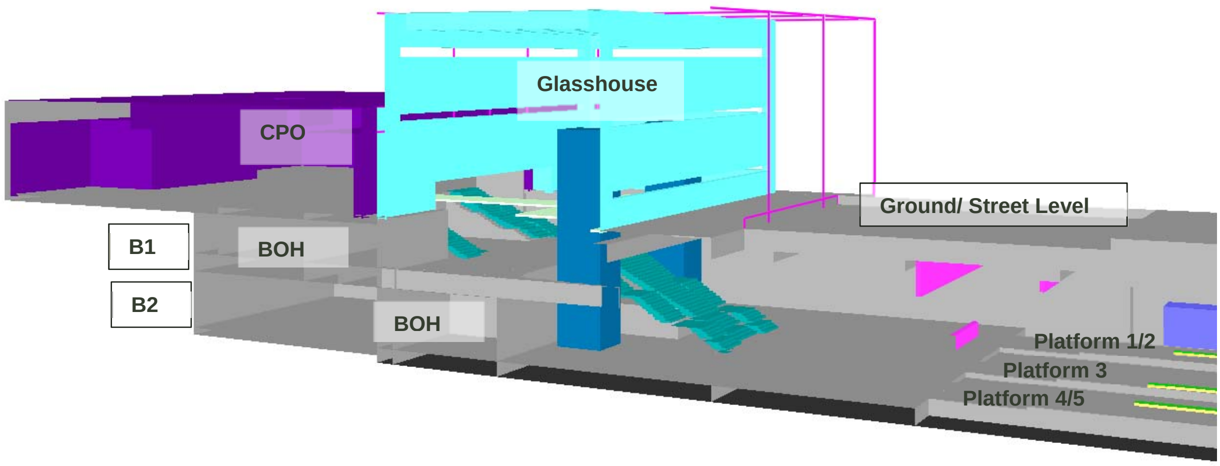


Figure 8: CPO and Britomart West – Permanent Works

Note: Temporary Accommodations at Level B2 between the platforms and the glasshouse not modelled. These are fire separated from the surrounding space and sprinkler protected.

In the Permanent Works the new fire intervention stair on Platform Level (B2) of Britomart West will be available. This stair serves the Platform Level only and discharges into a fire lobby within CPO on the Ground Level which in turn discharges to the exterior at the northeast corner of the CPO building.

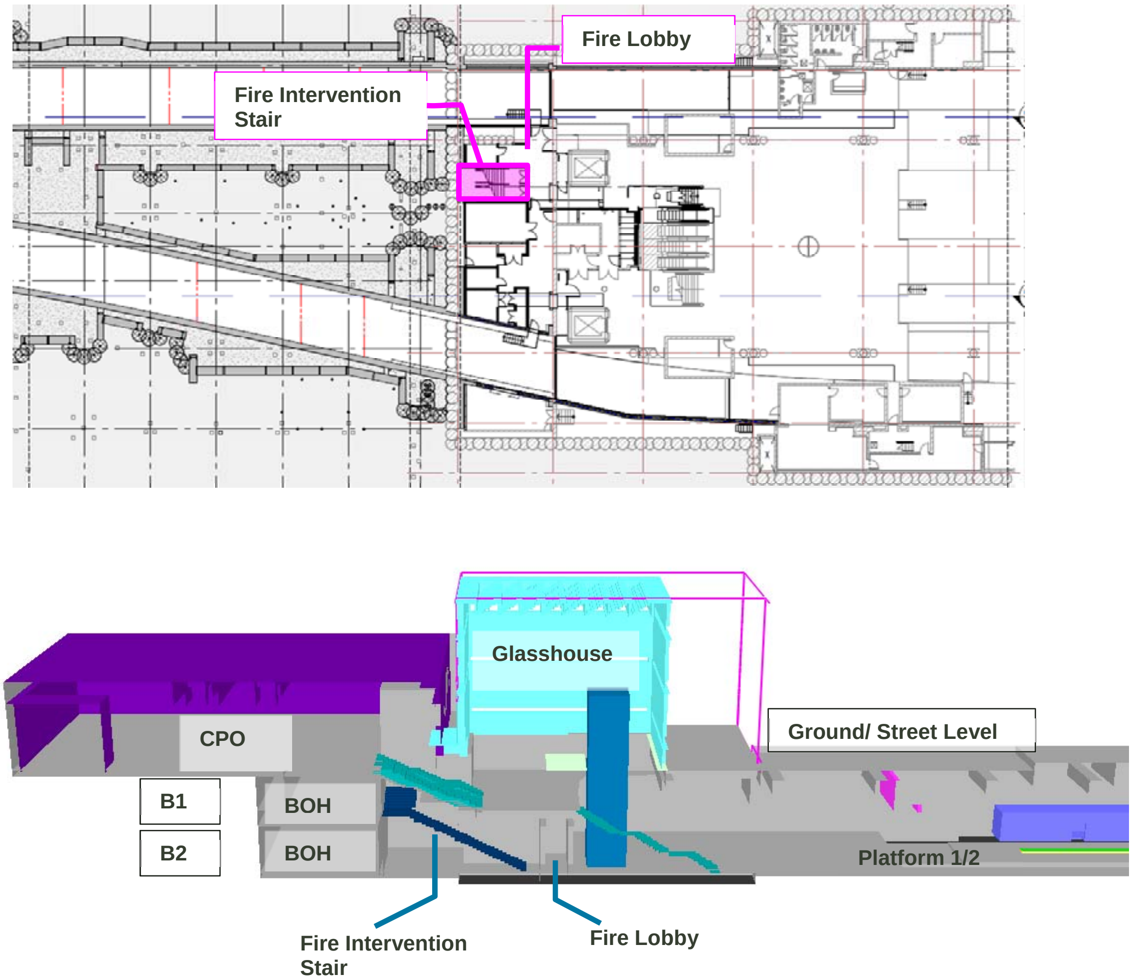


Figure 9: Britomart West – Permanent Works, Fire Intervention Stair

FDS Parameters

The following outlines the FDS parameters used for the Britomart Station models. It is noted that where possible, the same assumption used by Stacey Agnew in the existing consent documents has been used in the current assessment. This is to maintain modelling conditions as consistent as possible to provide a reasonable comparative assessment.

Inputs		Comments
Model geometry	As per drawings	
Grid resolution (4 < D*/δx < 16)	0.10 ~ 0.40 0.15 ~ 0.60	Based on Q = 4.0 MW Based on Q = 10.0 MW
Mesh size	0.2 m x 0.2 m x 0.2 m 0.4 m x 0.2 m x 0.2 m	Britomart Station and Glasshouse CPO, Crossover and Tunnel
Simulation time	Begins: -60 seconds Ends approximately: 1200 seconds	From -60 seconds to 0 seconds the model is run with the initial ventilation conditions to allow the system to start in equilibrium. Model is run until at least • 1.5 x RSET for base cases and • RSET for sensitivity & redundancy cases
Fuel type*	Polyurethane, $C_{6.3}H_{7.1}P_{2.1}N_1$	Consistent with Stacey Agnew Report.
Soot yield	0.051 kg_{soot} / kg_{fuel}	Yields based on average of major internal lining materials used in Sydney Generation 2 EMU rolling stock (from previous Arup studies). These values are considered conservative for materials used in AM Class EMUs which are constructed to BS6853 category 1b and are therefore to a higher level of material fire performance (with stricter controls on material heat release rate and smoke emission opacity)
CO yield rate	0.026 g/g	
Visibility Factor	2.0	Appropriate for reflective surfaces (e.g., walls)
Heat release rate per unit area (HRRPUA)	HRRPUA = 250 kW/m^2	Based on the fire size within the carriage; the fire is horizontally located and distributed throughout the floor
Smoke Curtains (West)	Existing 2 m deep smoke curtains beneath the roof: at Grid X211 000. Existing 1 m smoke curtains beneath the north and south exhaust plenum: at Grid X211 000. Deployment time: 30 s after system activation. Redundancy case: Smoke curtains fail to deploy.	Consistent with Stacey Agnew Report. Note: deployment time measured by Stacey Agnew as 21 s.

Inputs		Comments
Smoke Baffles (Platform East)	Glass downstands in front of the entrance to escalators and stairs, with the bottom of glass downstand to be 2.5m above floor, with full height separation on both sides of the escalators and stairs.	Consistent with Stacey Agnew Report.
Supply via Britomart East	Defined boundary condition based on 1D model.	See below for calculations and justification
Open louvres in the Glasshouse	Louvre openings shall be returned to pre-enabling works conditions. To simplify the louvres in the FDS model inputs: Equivalent open area in the FDS model: 37.5 m^2 in each elevation 3 off 18.8 m long x 0.6 m high on all four faces	Consistent with Stacey Agnew Report. In FDS the Glasshouse is the only free boundary, other bounding conditions defined by 1D network modelling of the airflows. Louvres on each elevation are evenly distributed. See below for calculations and justification
Doors in the Glasshouse	N/A	In the event of an emergency, occupants will evacuate through these doors so they are likely to be open however a conservative assumption is that they are closed, in order to ascertain the likely maximum airflow through the louvres.
Temporary Accommodation	N/A	Removed once Temporary Works are complete
Doors in CPO	N/A	In the event of an emergency occupants will evacuate through these doors so they are likely to be open; however, it has been assumed that they are closed in order to ascertain the likely maximum airflow through the louvres.
Smoke Exhaust	At t = 0 s: running at 30 % (105 m^3/s) 60s ramp-up time to 100 % (350 m^3/s) after activation Flow rates defined based on 1D model. Redundancy case: 50% Exhaust capacity in Britomart Station	See below for calculations and justification Note: Stacey Agnew measured ramp up time from 30% to 100% of 10 s. Redundancy case based on SCADA node failure.
Supply Air	At t = 0 s: running at 30 % (55 m^3/s) 60 s ramp-down time to 0 % (0 m^3/s) after activation	Input into 1D model. See below for calculations and justification

Inputs		Comments
Tunnel	Defined flow boundary condition based on 1D model.	In Fire Mode, Britomart Place and Tangihua vents are not assumed operational for Permanent Works conditions. See below for calculations and justification
Boundary Conditions	Station Structure 'CONCRETE' (thermally thick) Glass elements 'GLASS' Train carriage 'ADIABATIC' Temp stairs 'Steel' 6mm thick	Updated from C1 FEB, in general consistent with Stacey Agnew Report Train Carriage: system-wide assessment used 'steel'. Stacey Agnew Report used a composite material. References: Concrete – J.P, 1986. Heat Transfer, Sixth. ed. McGraw-Hill Glass – ASHRAE Fundamentals Handbook, 1997 Steel – Buchanan, A, Structural Design for Fire Safety,
Ambient Temperature	20°C	
Wind Conditions	Not modelled	Prevailing wind condition: NW at approximately 10 knots.
Heat Flux perpendicular to train door	In front of train door, from the edge of the platform on Platform 1: • 3 m • 6 m	To determine if occupants can egress past the carriage of fire origin. On Platform 1, 6 m is the far edge of platform On Platform 3, 6 m from the edge of the platform will be located on Track 4.
Heat Flux Devices	18 off, 1.5 m above platform level 20.0 m spacing	Located centrally along each platform Located at 1.5m above floor level to permit assessment in accordance with NZBC C3.8 "the maximum radiation flux at1.5 m above the floor is no greater than4.5 kW/m²…"
Other Outputs	Slice files presented: • 2m above platform floor, concourse floor, glasshouse floor. • Through the centre of the station (apx middle of Platform 3)	Plot 3D - 30 seconds Slice – 6 seconds Devices – 1 second HRR – 1 second

Ventilation Conditions

The capacities and response mode proposed for use have been discussed with stakeholders during consultation meetings held on 11 August 2015, 15 September 2015, 20 October 2015, and 17 November 2015. Refer to Temporary Works assessment for the calibration of the 1D model.

Base Case Flows

The proposed mode of operation during a station platform emergency is to operate only the station exhaust at 100% capacity, shut the supply air off, and draw all make-up through the glasshouse and east entrances. This is a modification to both the pre-Enabling Works and Temporary Works operating mode responses as shown below.

Table 3: SCADA Response Modes Pre Enabling Works (Pre EW), during the Temporary Works (TW), and Permanent Works (PW) Stage

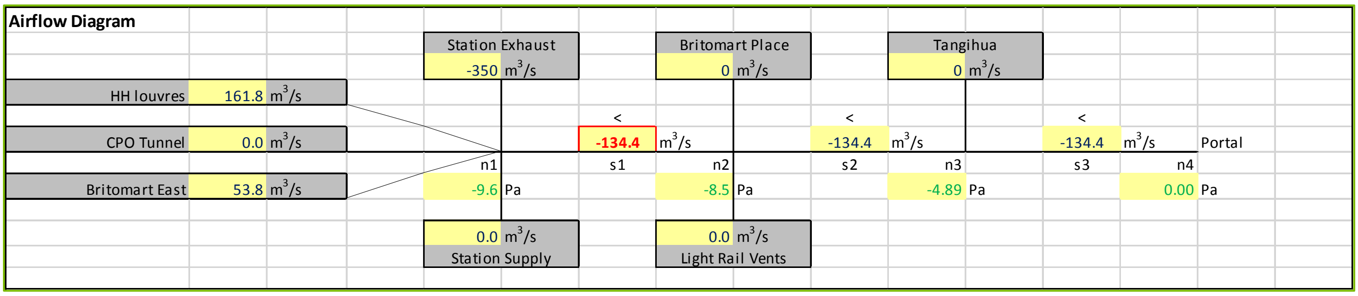
Stage	Ventilation Strategy	Station Supply Fans	Station Transfer Fans	Station Exhaust Fans	Britomart Place	West Tunnel Jet Fans	Tangihua Street Exhaust Fans	East Tunnel Jet Fans
Pre EW Calibration	Fire at Station Platforms	Off	Off	Exhaust*	Exhaust	4 fans to east	Off	Off
Pre EW [1]	Fire at Station Platforms	Off	Off	Exhaust*	Exhaust	2 fans to east	Off	Off
TW	Fire at Station Platforms	Off	Off	Exhaust 350 m^3/s	Exhaust 180 m^3/s	Off	Exhaust 180 m^3/s	Off
PW	Fire at Station Platforms	Off	Off	Exhaust 350 m^3/s	Off	Off	Off	Off

* Supply and exhaust indicate that all fans are operating at 100% capacity.

[1] Current consented ventilation strategy (Stacey Agnew FER rev 7 onwards), during detailed design it was proposed to maintain this strategy. Refer Existing Ventilation Section of this Appendix.

The capacities used for the modelling have been taken from the Support Phase – Britomart Station Review 228072-AC-RPT-085. The station exhaust capacity to be used is the nameplate capacity (350 m^3/s) of the fans, not the measured flow (407 m^3/s) determined during the 2006 assessment, as this provides a margin of safety over the design capacity.

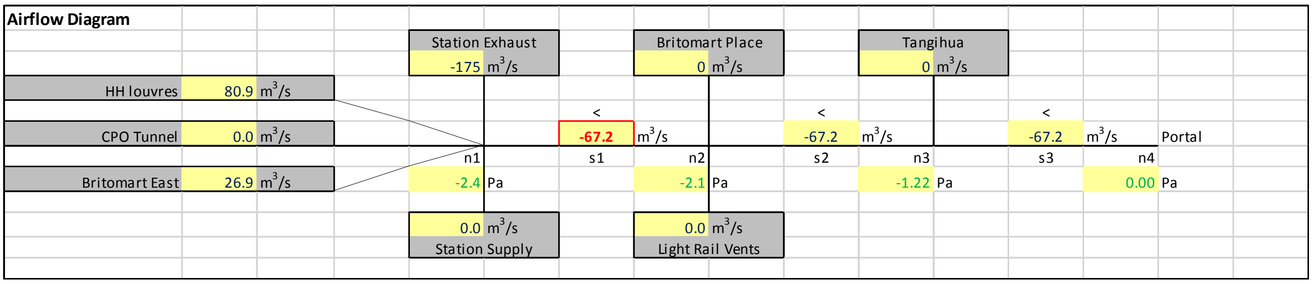
Flows will be constrained at select model boundaries (Tunnels and Britomart East), to allow flow conditions, in the appropriate quantity, to be predicted at the glasshouse. The approach effectively captures the relative pressure drops at make-up air locations throughout the station.



The resulting makeup air split is 46 % West : 54 % East. The makeup air from the west is wholly through the Glasshouse louvres, the makeup air from the east is through a combination of air paths through Britomart East and from the tunnels.

Redundancy Flows (50% mechanical ventilation)

The redundancy case (worst case with respect to exhaust from Britomart Station) would be the loss of the SCADA link to one of the MCCs which results in losing half of the exhaust capacity of the Over Track Exhaust (OTE) capacity within Britomart Station, and all capacity to one of the two exhaust plenums. The model considered failure of the north side exhaust, as this is considered 'worst case' as it's the plenum over the design fire location.



The resulting makeup air split is 46 % West : 54 % East. The makeup air from the west is wholly through the Glasshouse louvres, the makeup air from the east is a combination of air paths through Britomart East and from the tunnel.

Results

From the results from the Temporary Works fire scenarios, the base cases were rationalised to T1-W and T1-E. The 'worst case' fire location was T1-W as the fire plume is disrupted by the plenum above.

As such the sensitivity and redundancy cases were modelled at the worst base-case location (T1-W).

Fire Scenario		Fire Location	Simulation Time	Britomart East ASET Time [s]*	Britomart West ASET Time [s]	Comments
1P	Base Case	T1-W	1,200	> 1,200	> 1,200	
3P	Base Case	T1-E	972	> 972	> 972	Britomart East Platform 1/2 exit unavailable due to tenability criteria within the vicinity of the exit being exceeded
5P	Sensitivity - 10MW fire	T1-W	1,200	> 1,200	B2: 690 B1: > 1,200 GL: > 1,200	Visibility immediately in front of the exits remains clear for the duration of the model. For the rest of the Britomart West B2, the visibility drops intermittently in discrete areas from approximately 600 seconds onward; however, in accordance with the NZBC Clarification C4.3, tenability is not exceeded until 690 s.
6P	Redundancy - 50% Exhaust	T1-W	1,200	> 1,200	B2: 630 B1: > 1,200 GL: > 1,200	Visibility immediately in front of the exits remains clear for the duration of the model. For the rest of the Britomart West B2, the visibility drops intermittently in discrete areas from approximately 250 seconds onward; however, in accordance with the NZBC Clarification C4.3, tenability is not exceeded until 630 s.
7P	Redundancy - no smoke curtain	T1-W	852	> 852	B2: 396 B1: > 852 GL: > 852	Visibility immediately in front of the exits remains clear for the duration of the model. For the rest of the Britomart West B2, the visibility drops intermittently in discrete areas from approximately 250 seconds onward; however, in accordance with the NZBC Clarification C4.3, the tenability is not exceeded along the egress paths until 396 seconds.

* The concourse at Britomart East is effectively separated from the effects of fire and has indefinite tenability in a station fire event. There are enclosures around the stairs/escalators and make-up air being drawn down through the stair/escalator openings, effectively keeps the escape route clear of smoke in a fire event.

For a complete set of the results refer to Appendix I.

Fire Scenario 1 – T1-W 4 MW

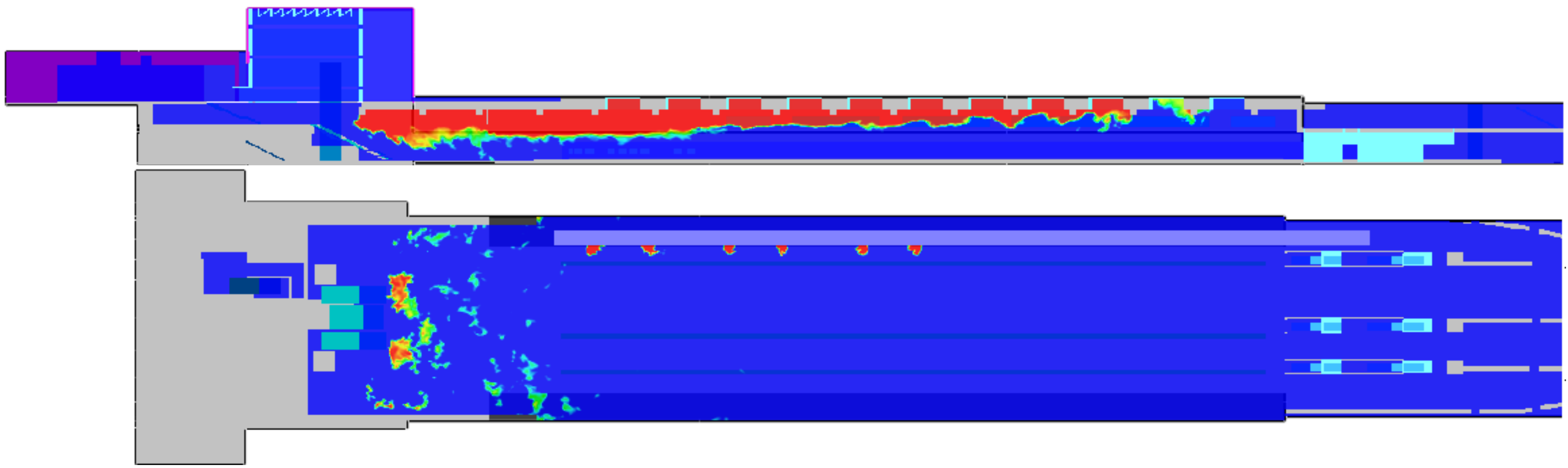
Visibility

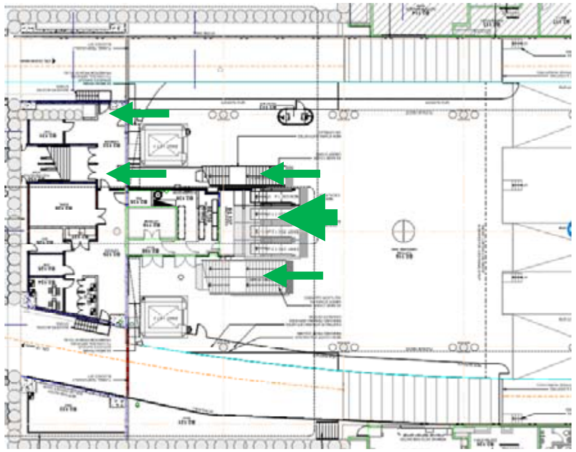
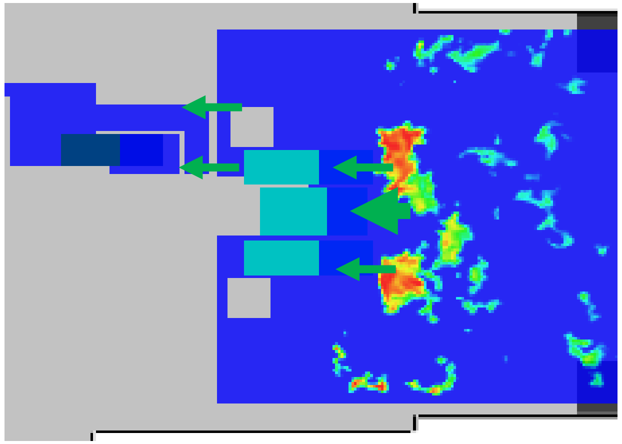
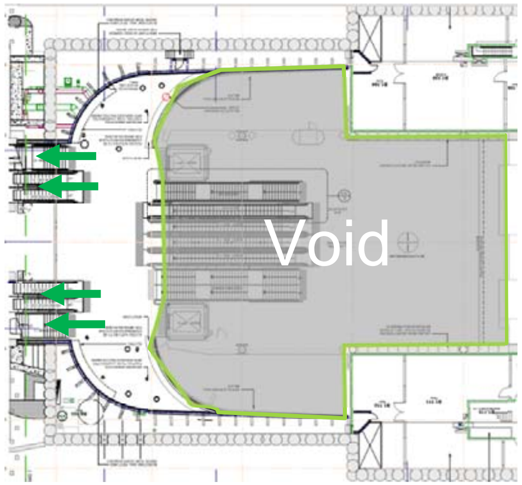
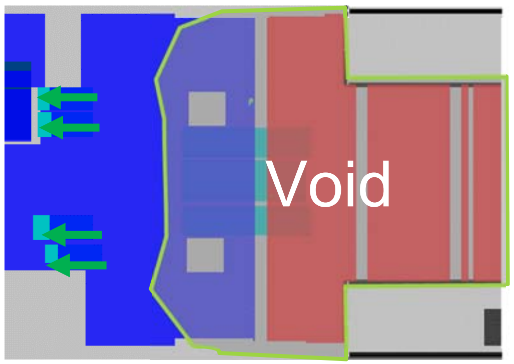
Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (1,200 s).

In this fire scenario the tenability is considered to be > 1,200 seconds.

Platform Level



<table>
<tr><th colspan="2">Fire Scenario 1 – T1-W 4 MW</th></tr>
<tr><td>Britomart West Platform (B2)
</td><td>Plan view at 2.0 m above B2 floor level
</td></tr>
<tr><td>Britomart West Concourse (B1)
</td><td>Plan view at 2.0 m above B1 floor level
</td></tr>
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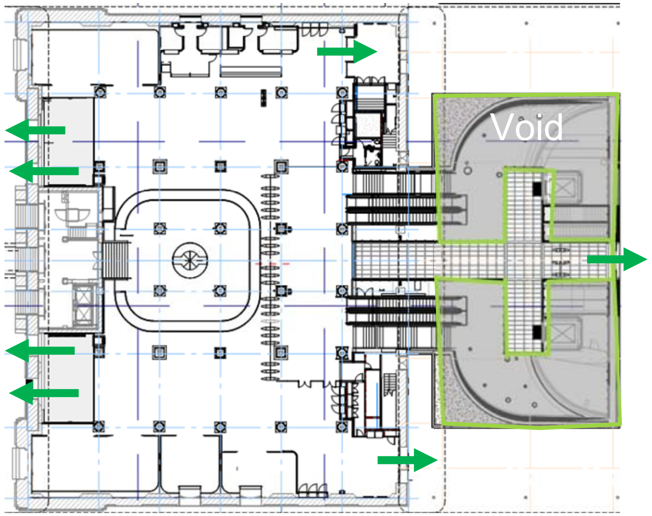
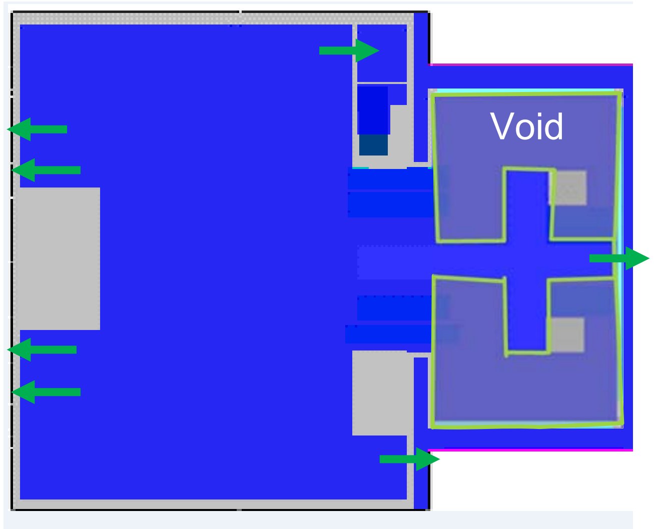
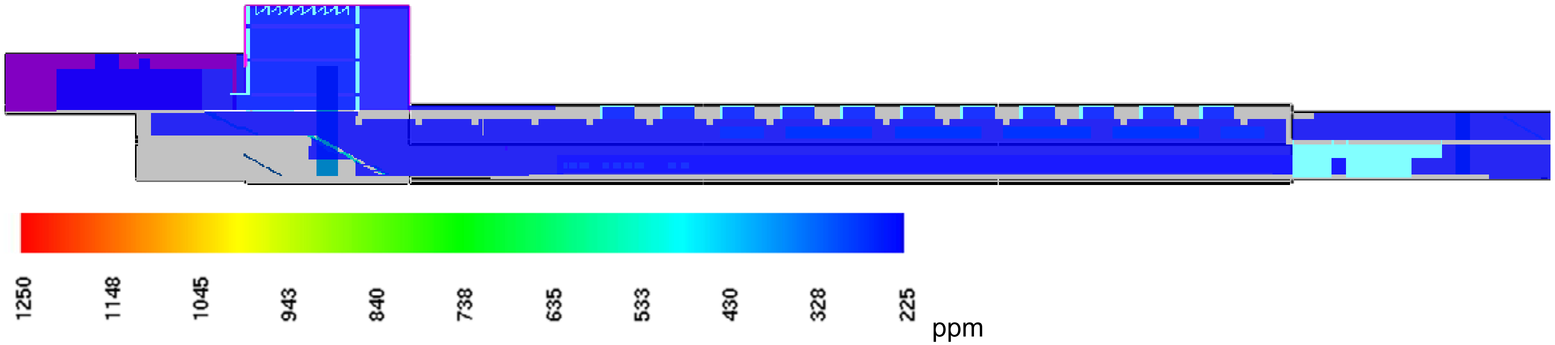
Fire Scenario 1 – T1-W 4 MW	
Glasshouse	Plan view at 2.0 m above Glasshouse floor level
	

Fire Scenario 1 – T1-W 4 MW

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

$FED_{CO} = (\varphi_{CO}/35,000)*\Delta t$

$FED_{CO} = (225/35,000)*20$

$= 0.129$ (≤ 0.3 acceptable).

Fire Scenario 1 – T1-W 4 MW

FED$_{Thermal}$

Tenability limit for FED$_{Thermal}$ is exceeded when the FED$_{Thermal}$ is greater than 0.3

FED$_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

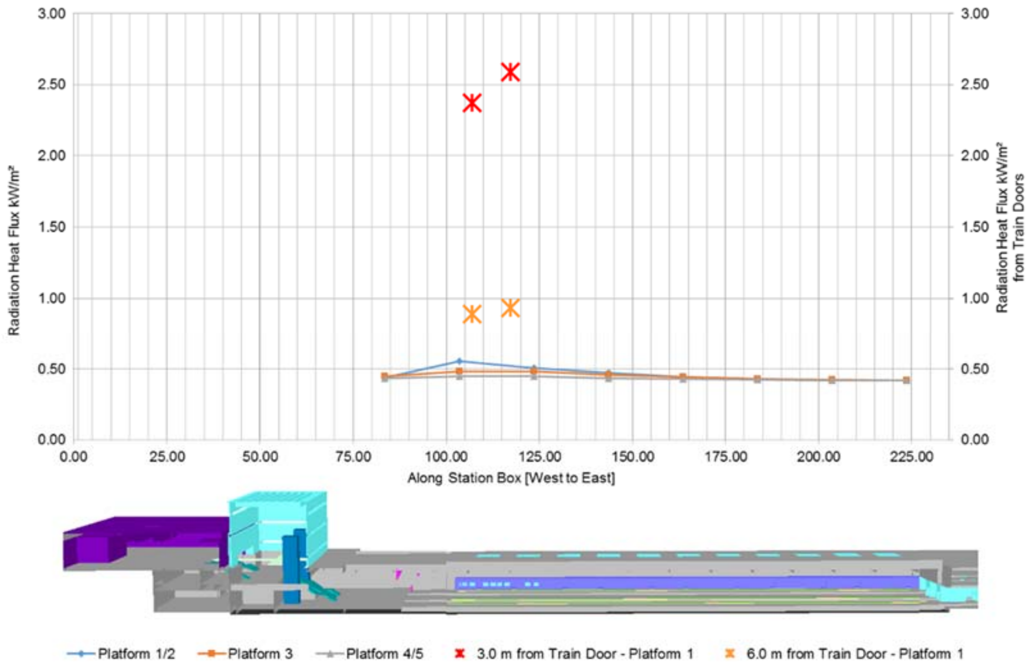
<u>Radiant Heat</u>

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

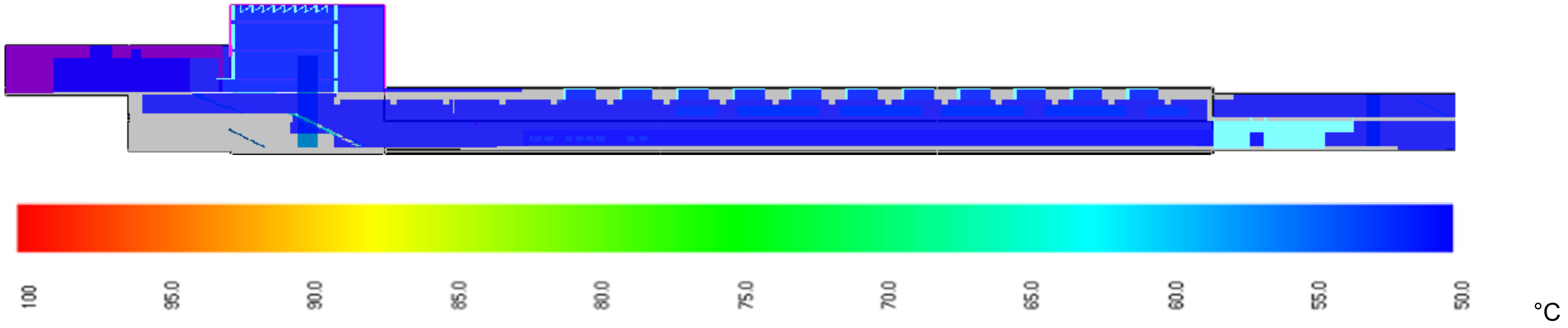
Therefore radiant heat can be discounted in the in FED$_{Thermal}$ calculation.

Radiant heat flux was also measure in front of the open train doors. Occupants can evacuate past the carriage of fire origin along the platform at least 3.0 m from the train door, where they are exposed to a maximum of 2.6 kW/m². Onset of pain occurs after being exposed for $t_p = (35/\dot{q}''_r)^{1.33} = (35/2.6)^{1.33} = 32$ seconds. Occupants will pass the exposure from the train door in a matter of seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 1 – T1-W 4 MW

<u>Convective Heat</u>



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.064$ ($\leq$ 0.3 acceptable)

Fire Scenario 3 – T1-E 4 MW

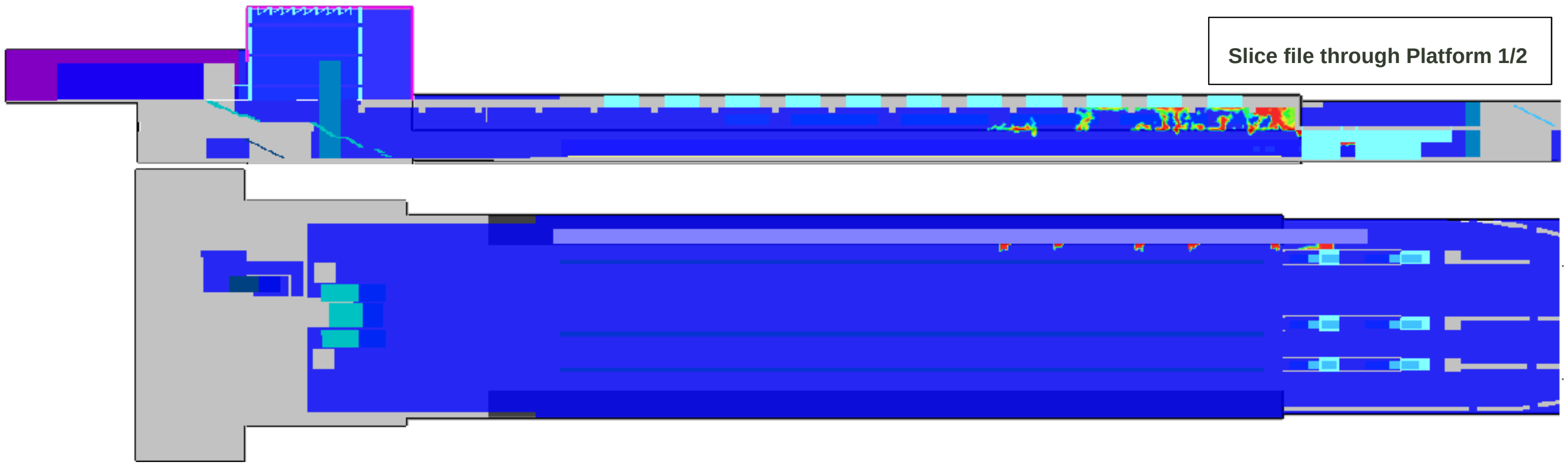
Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded does not occur within the duration of the simulation (972 s).

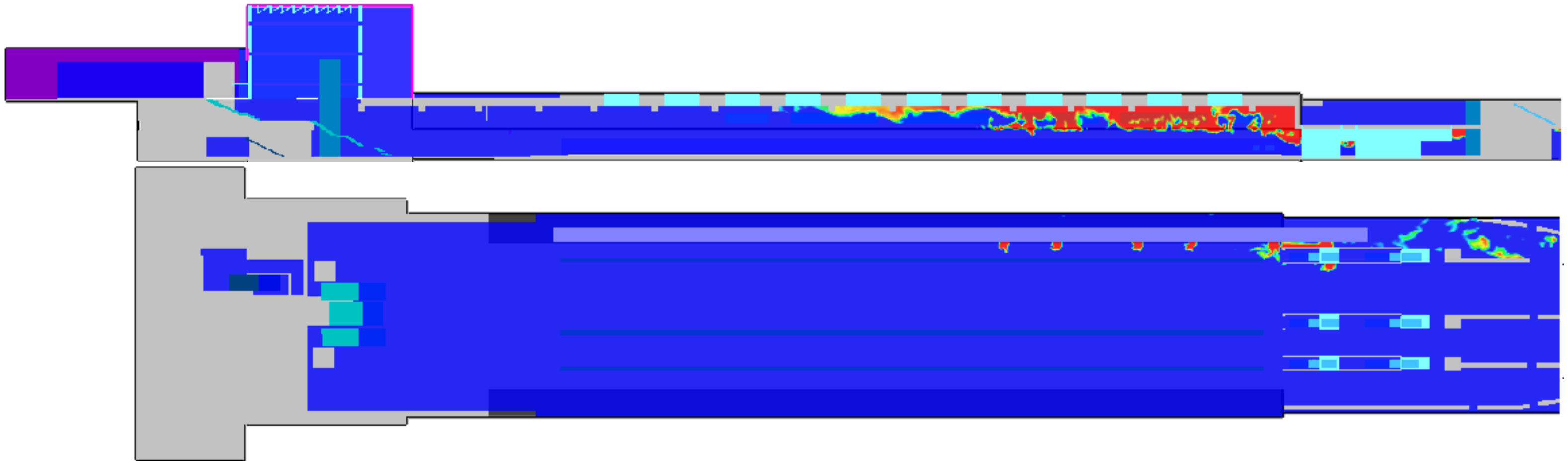
In this fire scenario the tenability is considered to be > 972 seconds, except the Platform 1/2 exits at Britomart East which are directly in front of the fire location. Based on Egress Case 4 the clearance time of Platform 1/2 is calculated to be 57 seconds

Platform Level: 60 seconds

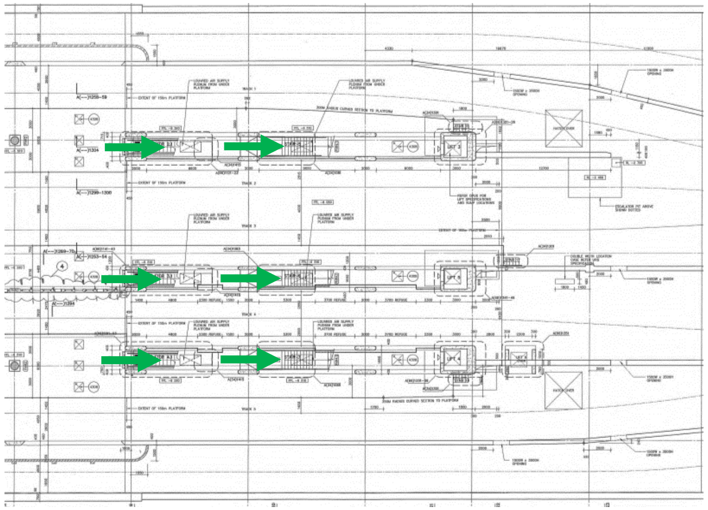
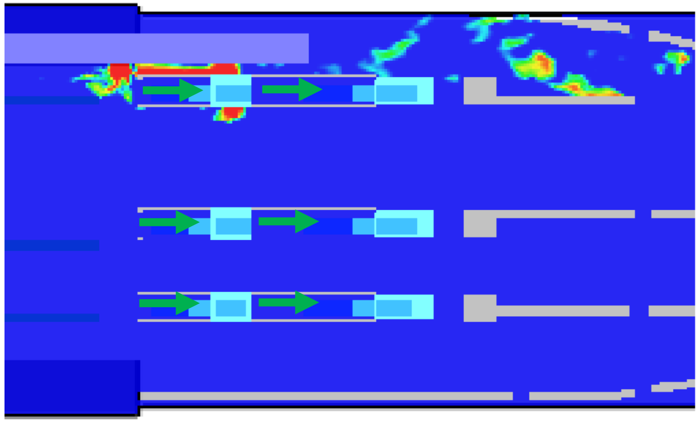
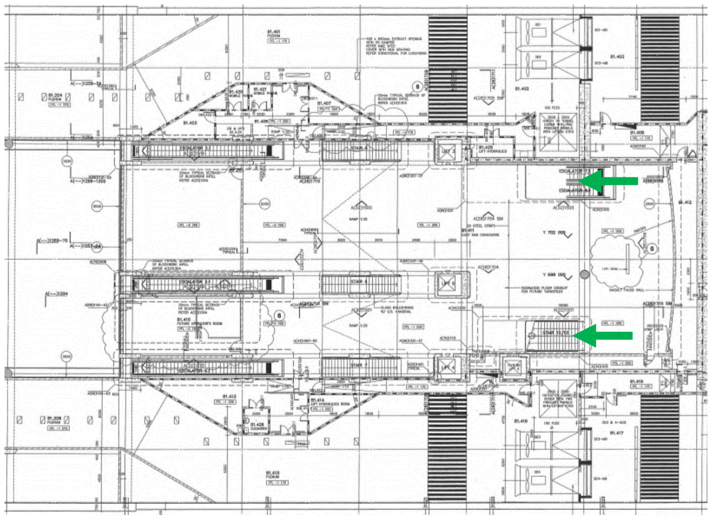
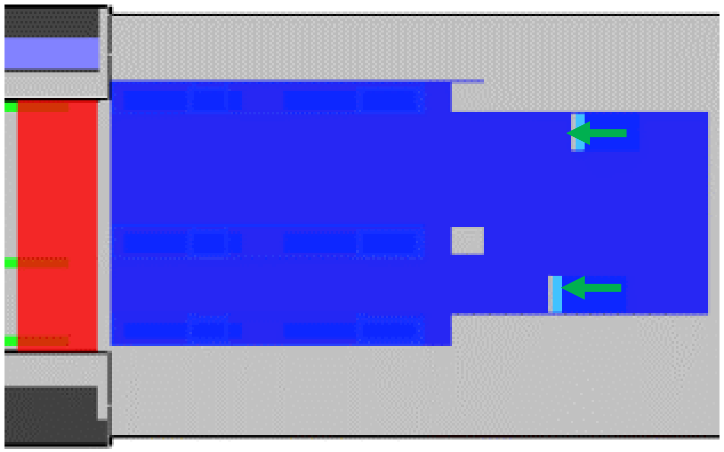


Fire Scenario 3 – T1-E 4 MW

Platform Level: 972 seconds

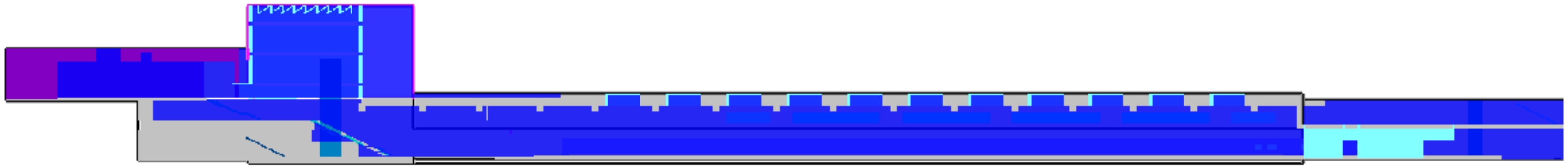


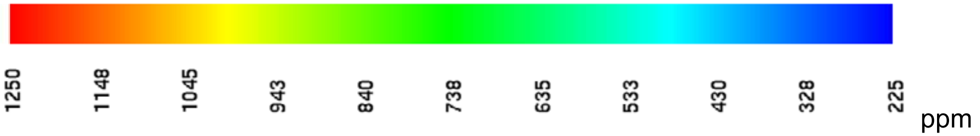
Fire Scenario 3 – T1-E 4 MW

Britomart East Platform	Plan view at 2.0 m above Platform floor level: 972 seconds
	
Britomart East Concourse (B1)	Plan view at 2.0 m above B1 floor level: 972 seconds
	

Fire Scenario 3 – T1-E 4 MW

FED_{CO}





Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (972 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (16.2 minutes)

FED_{CO} = $(\varphi_{CO}/35{,}000)*\Delta t$

FED_{CO} = (225/35,000)*16.2

= 0.104 ($\leq$ 0.3 acceptable).

Fire Scenario 3 – T1-E 4 MW

$FED_{Thermal}$

Tenability limit for $FED_{Thermal}$ is exceeded when the $FED_{Thermal}$ is greater than 0.3

$FED_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

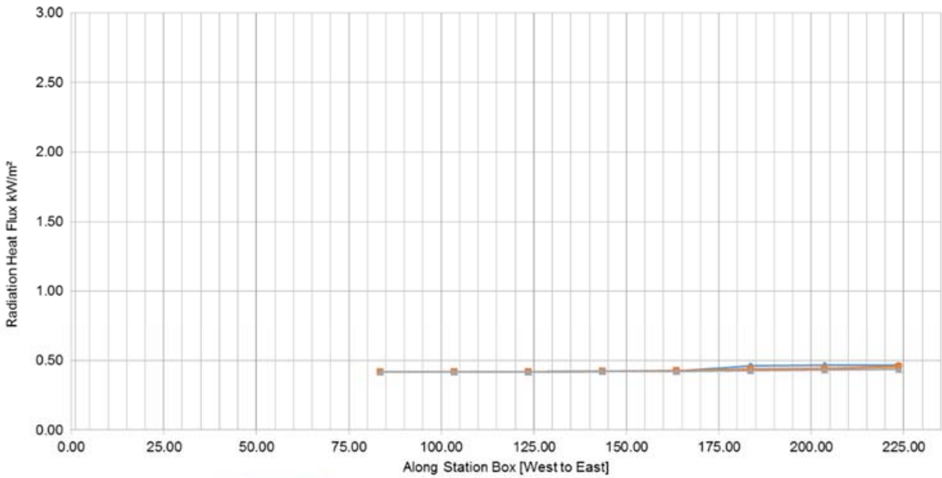
Radiant Heat

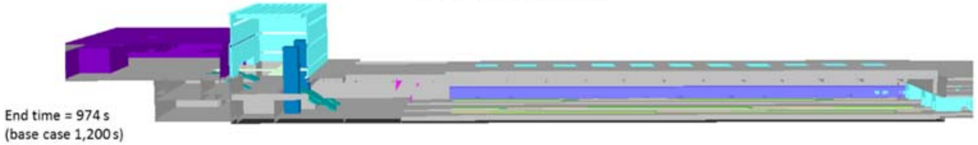
The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (972 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

Therefore radiant heat can be discounted in the in $FED_{Thermal}$ calculation.

As the design fire is the same as Fire Scenario 1 the radiant heat flux in front of the doors will be the same. However as the exits are directly in front of the design fire is it unlikely occupants will pass the fire to reach an exit. Egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.

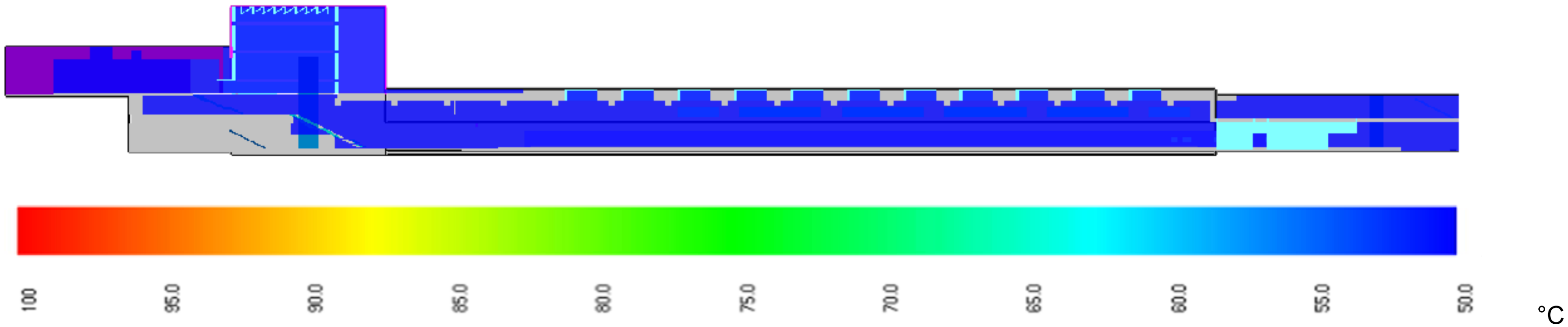




Platform 1/2 Platform 3 Platform 4/5

Fire Scenario 3 – T1-E 4 MW

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (972 seconds / 16.2 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*16.2$

$= 0.054$ (≤ 0.3 acceptable)

Fire Scenario 5 – T1-W 10 MW

Visibility

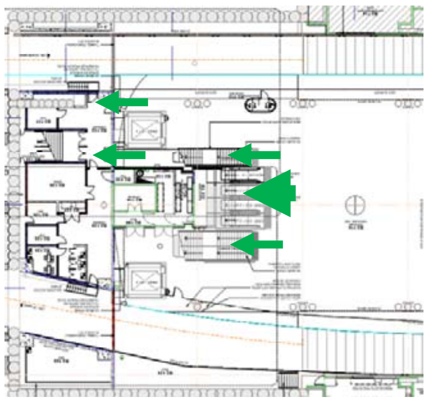
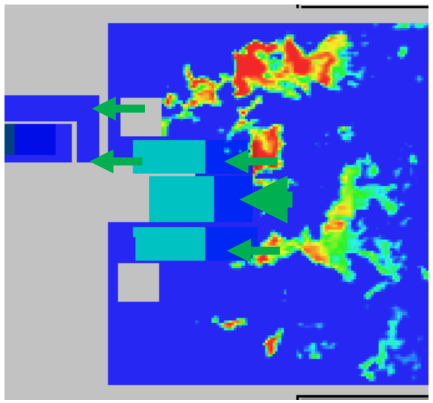
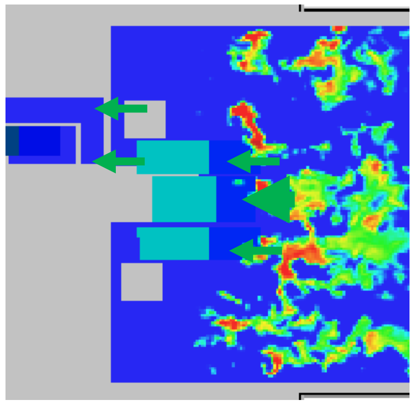
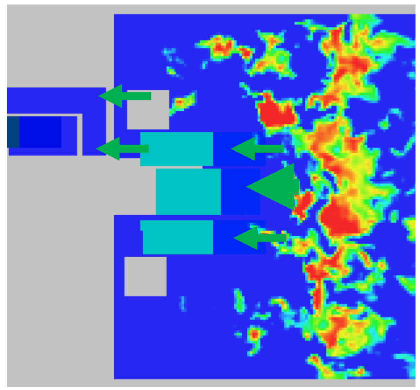
m

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded is demonstrated by the 30 seconds prior to the nominated ASET, the nominated ASET, and 30 seconds after the nominated ASET.

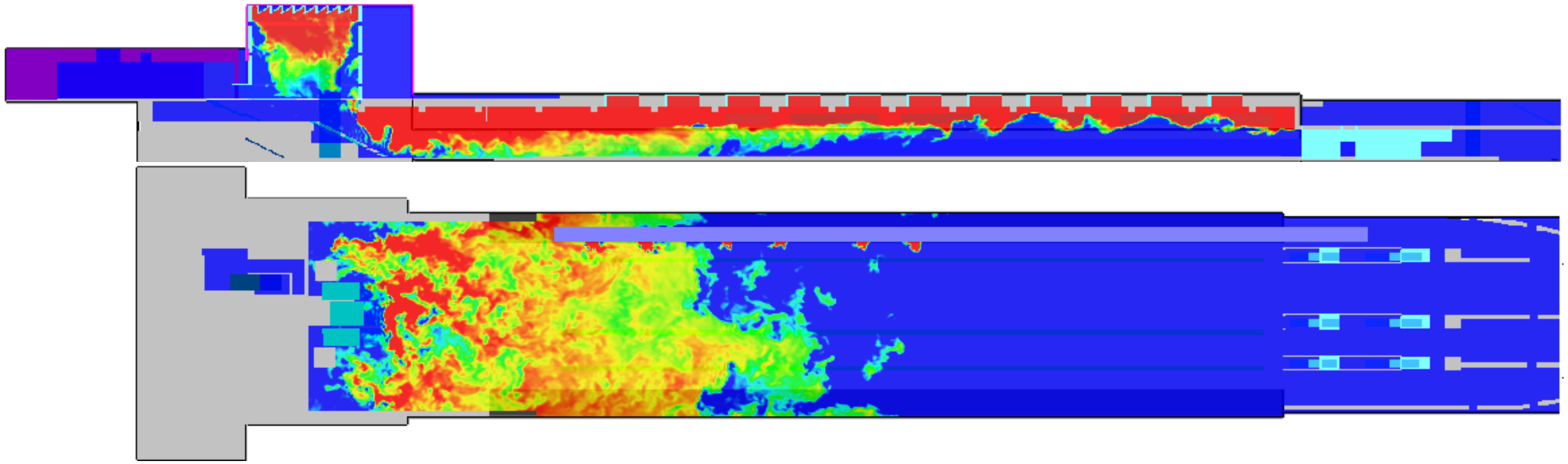
In this fire scenario, the tenability criteria is considered to be exceeded on Platform Level (B2) at 690 seconds.

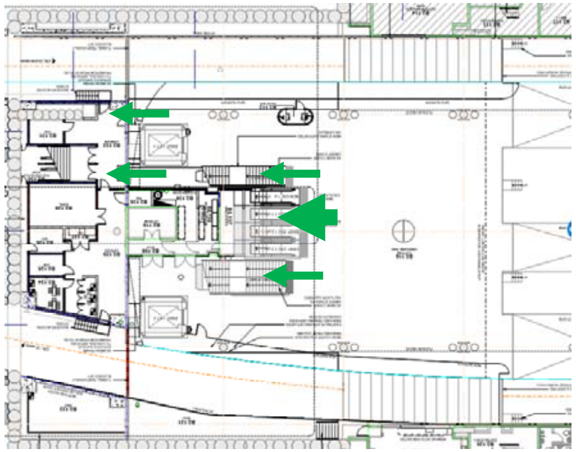
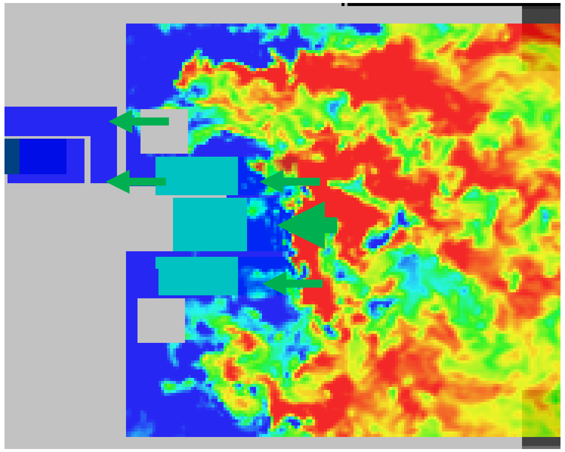
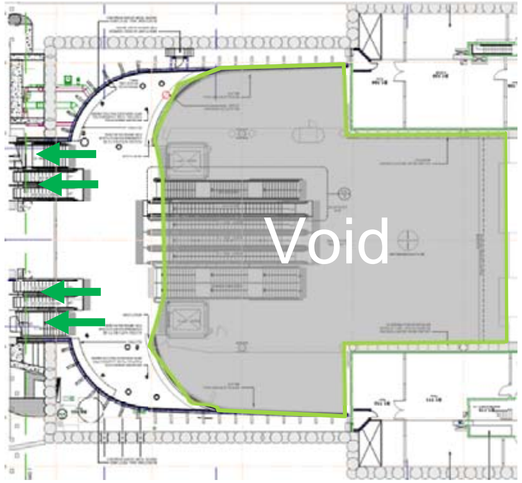
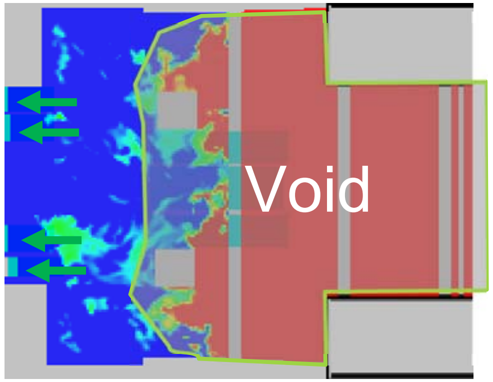
Tenability is considered to be maintained for > 1,200 seconds in all other areas.

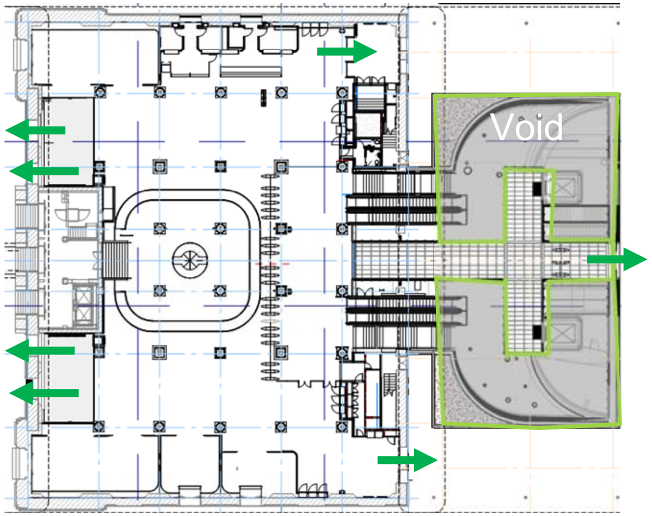
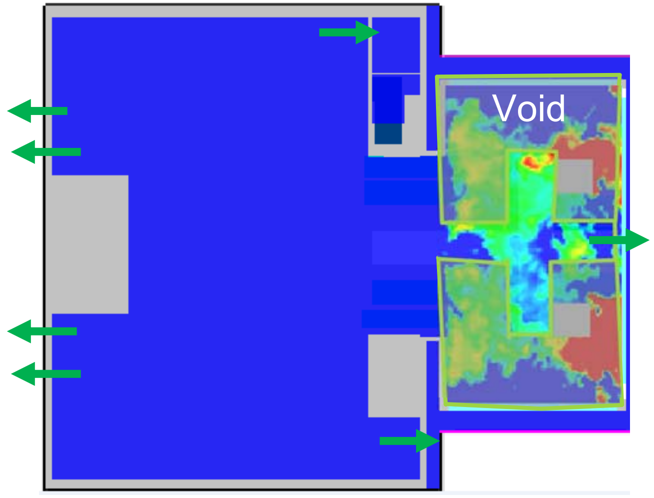
Platform Level: Britomart West Exits	T = 660 seconds	T = 690 seconds	T = 720 seconds
			

Fire Scenario 5 – T1-W 10 MW

Platform Level: T = 1,200 seconds

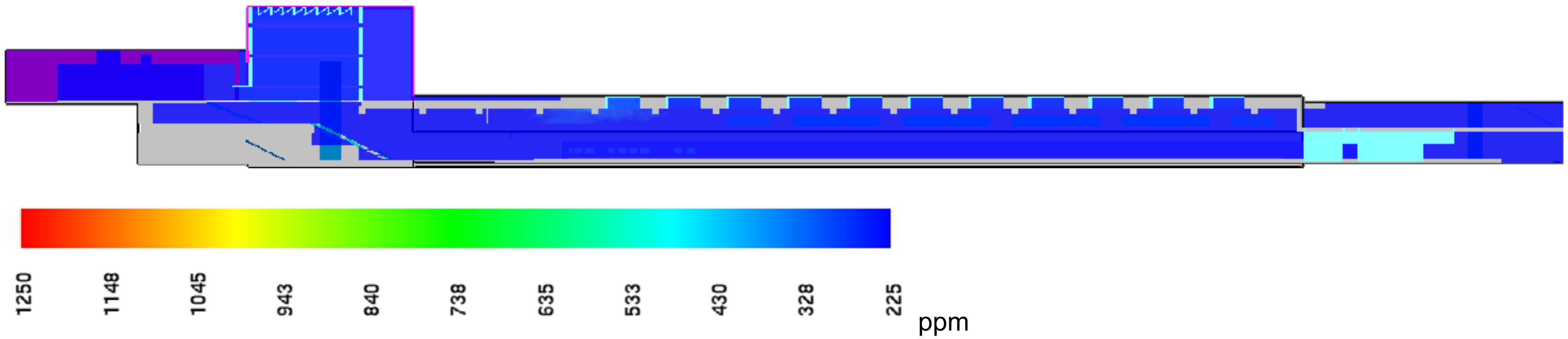


Fire Scenario 5 – T1-W 10 MW	
Britomart West Platform (B2) 	Plan view at 2.0 m above Platform floor level: 1,200 seconds 
Britomart West Concourse (B1)  	Plan view at 2.0 m above B1 floor level: 1,200 seconds 

Fire Scenario 5 – T1-W 10 MW	
Glasshouse	Plan view at 2.0 m above Glasshouse floor level: 1,200 seconds
	

Fire Scenario 5 – T1-W 10 MW

FED$_{CO}$



Tenability limit for FED$_{CO}$ is exceeded when the FED$_{CO}$ is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

FED$_{CO}$ = (φ_{CO}/35,000)*Δt

FED$_{CO}$ = (225/35,000)*20

= 0.129 ($\leq$ 0.3 acceptable).

Fire Scenario 5 – T1-W 10 MW

FED$_{Thermal}$

Tenability limit for FED$_{Thermal}$ is exceeded when the FED$_{Thermal}$ is greater than 0.3

FED$_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

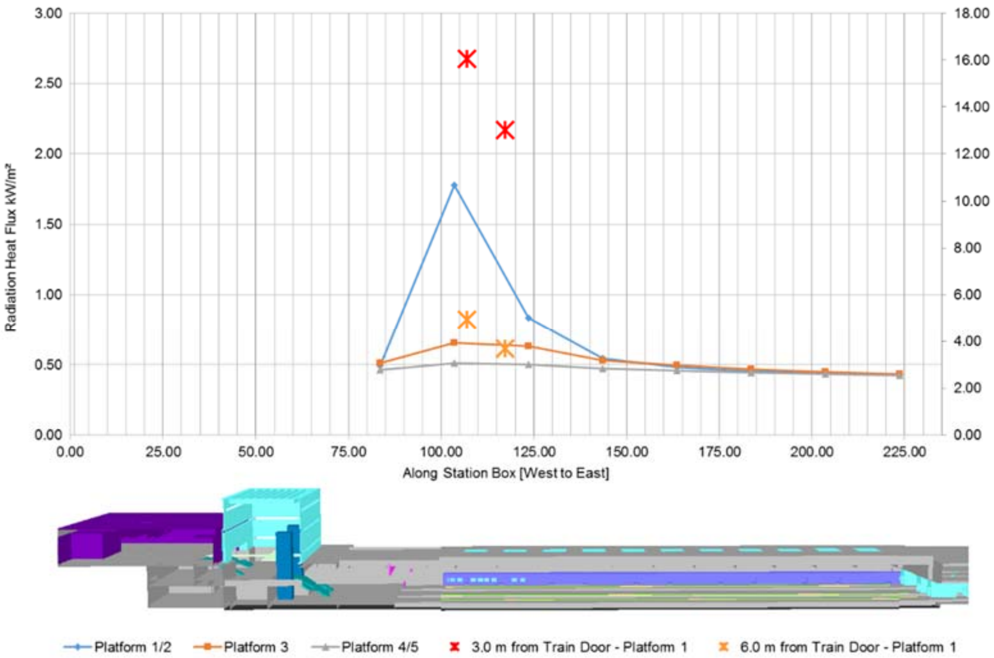
<u>Radiant Heat</u>

the upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

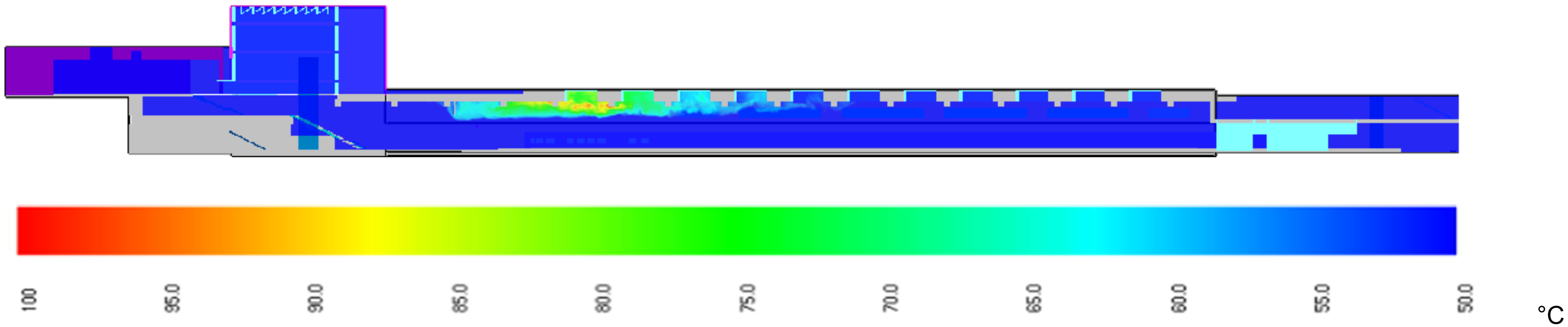
Therefore radiant heat can be discounted in the in FED$_{Thermal}$ calculation.

Radiant heat flux was also measure in front of the open train doors. Occupants on Platform ½ cannot evacuate past the carriage of fire origin along the platform as the radiant heat flux 3.0 m from the train door is 15.6 kW/m², this exceeds the maximum permissible under PD 7974: Part 6 of 10 kW/m², which causes onset of pain in 4 seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 5 – T1-W 10 MW

<u>Convective Heat</u>



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.064\ (\leq 0.3\ \text{acceptable})$

Fire Scenario 6 – T1-W 4 MW with 50% exhaust

Visibility

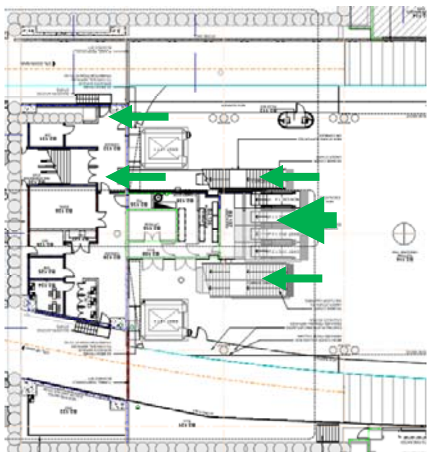
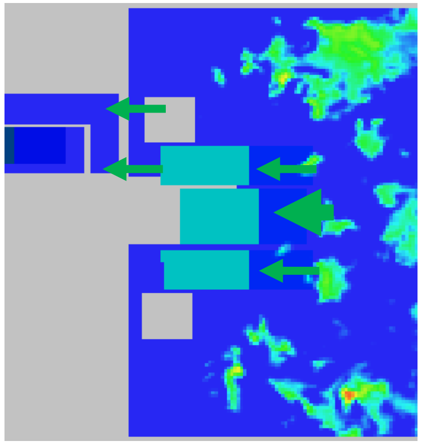
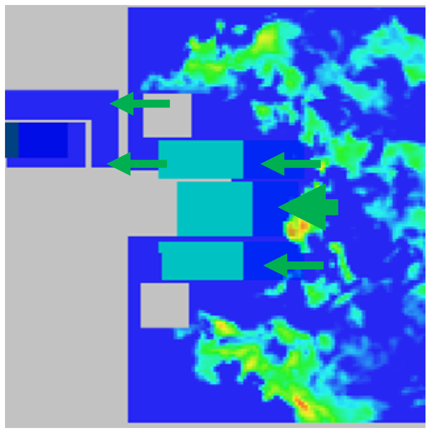
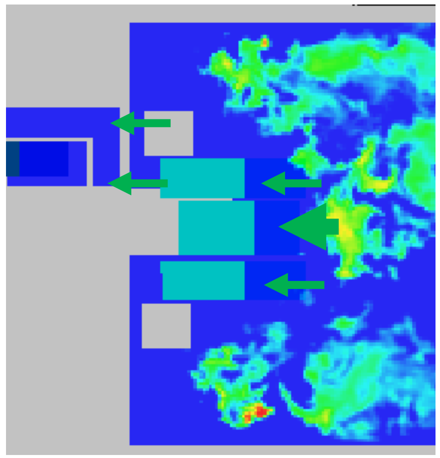
m

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded is demonstrated by the 30 seconds prior to the nominated ASET, the nominated ASET, and 30 seconds after the nominated ASET.

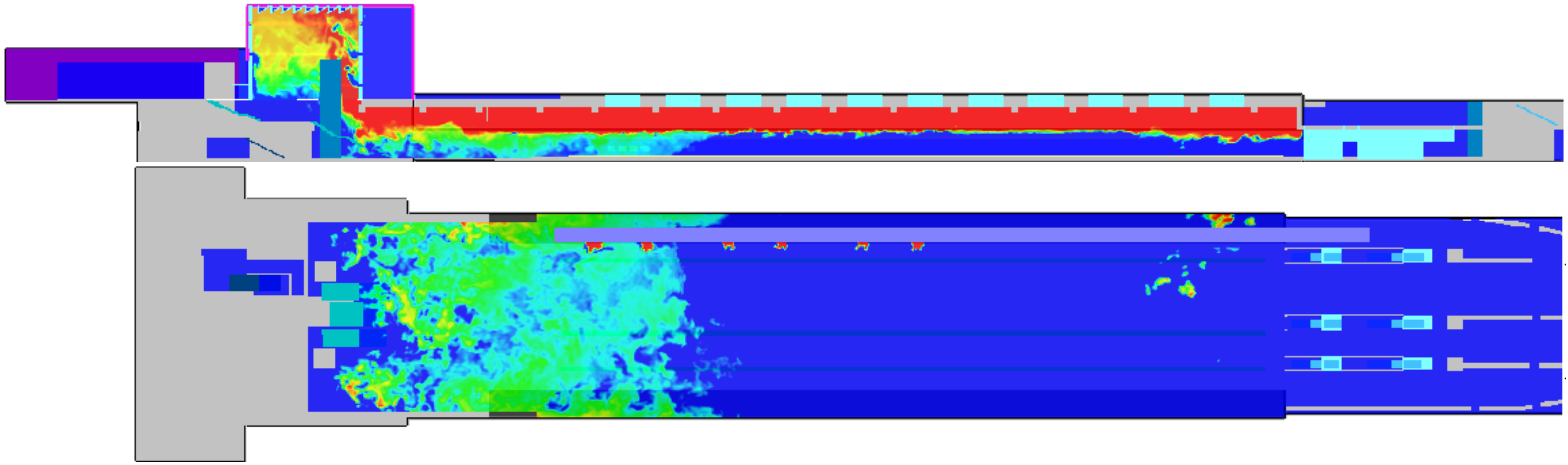
In this fire scenario the tenability criteria is considered to be exceeded on Platform Level (B2) at 630 seconds.

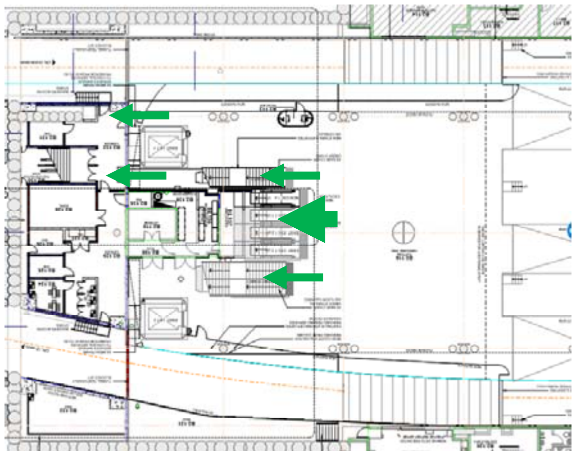
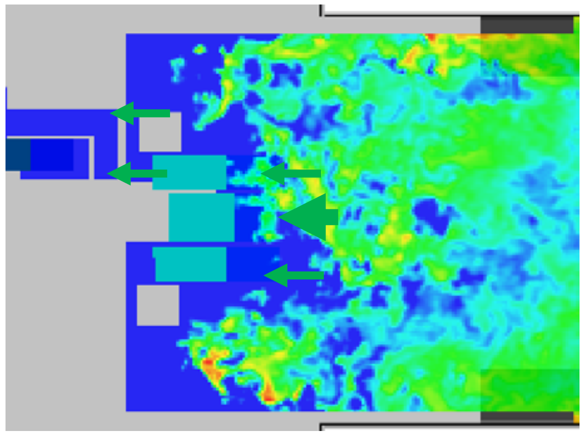
Tenability is considered to be maintained for > 1,200 seconds in all other areas.

Britomart West Platform (B2)	T = 600 seconds	T = 630 seconds	T = 660 seconds
			

Fire Scenario 6 – T1-W 4 MW with 50% exhaust

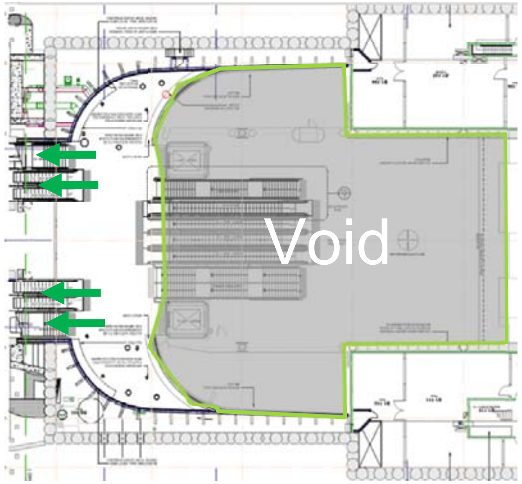
Platform Level: T = 1,200 seconds



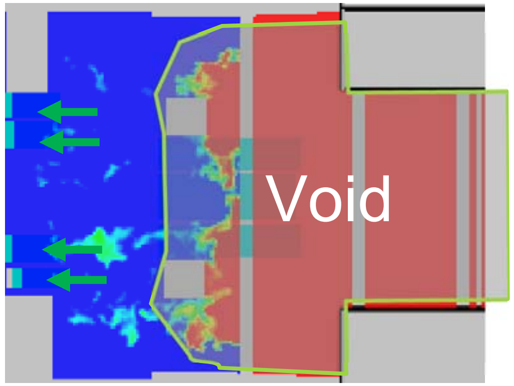
Britomart West Platform (B2)	Plan view at 2.0 m above B2 floor level: 1,200 seconds
	

Fire Scenario 6 – T1-W 4 MW with 50% exhaust

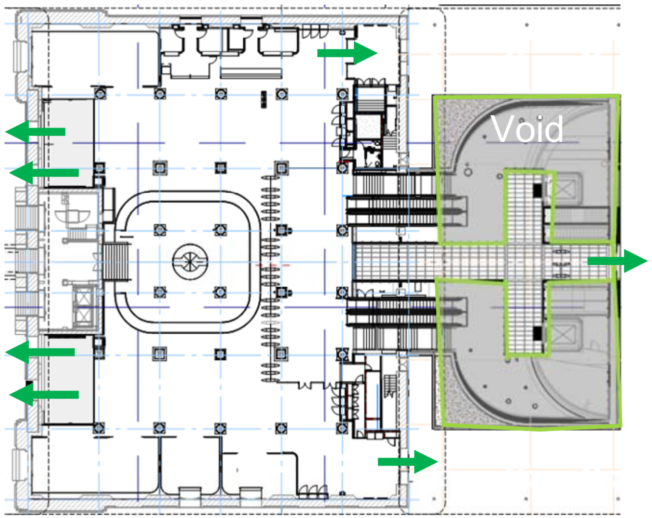
Britomart West Concourse (B1)



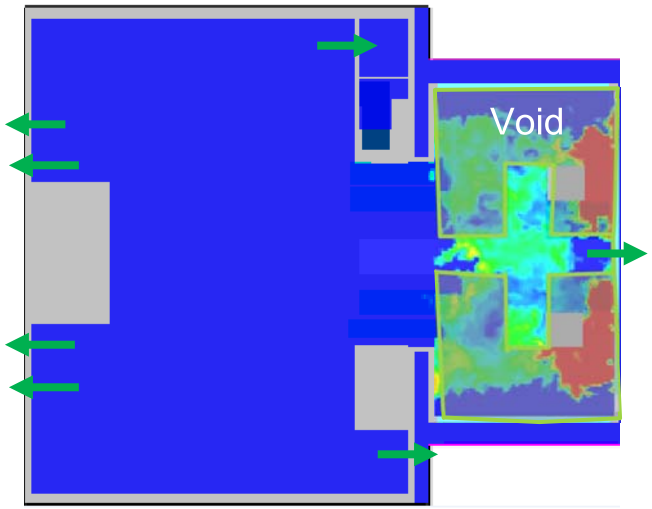
Plan view at 2.0 m above B1 floor level: 1,200 seconds



Glasshouse

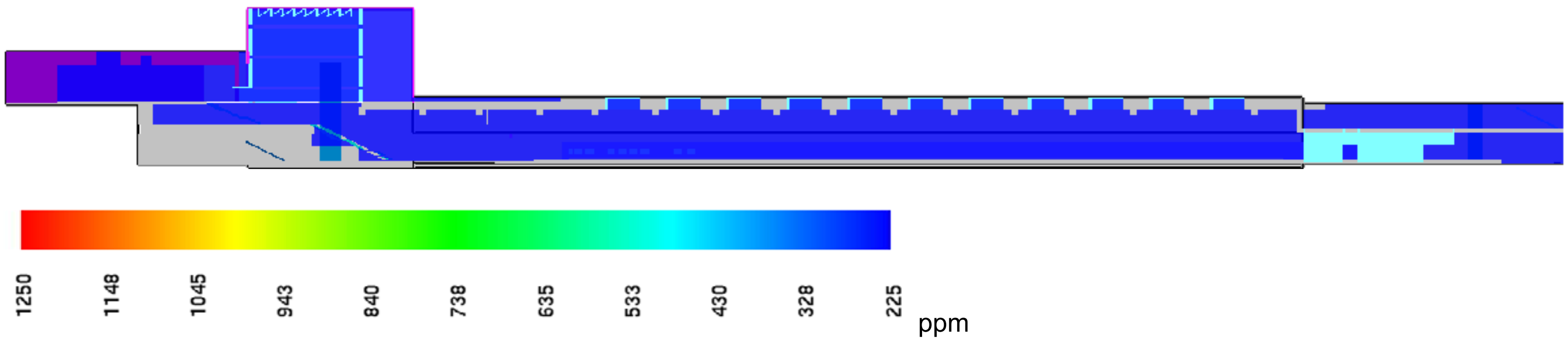


Plan view at 2.0 m above Glasshouse floor level: 1,200 seconds



Fire Scenario 6 – T1-W 4 MW with 50% exhaust

FED$_{CO}$



Tenability limit for FED$_{CO}$ is exceeded when the FED$_{CO}$ is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (1,200 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (20 minutes)

FED$_{CO}$ = (φ_{CO}/35,000)*Δt

FED$_{CO}$ = (225/35,000)*20

= 0.129 ($\leq$ 0.3 acceptable).

Fire Scenario 6 – T1-W 4 MW with 50% exhaust

$FED_{Thermal}$

Tenability limit for $FED_{Thermal}$ is exceeded when the $FED_{Thermal}$ is greater than 0.3

$FED_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

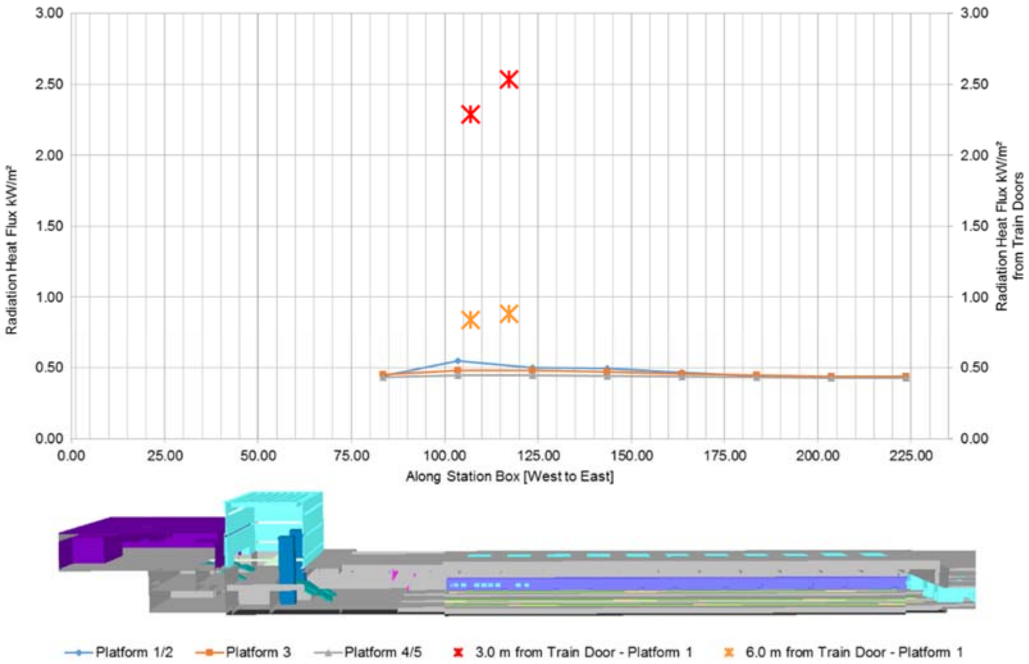
Radiant Heat

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (1,200 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

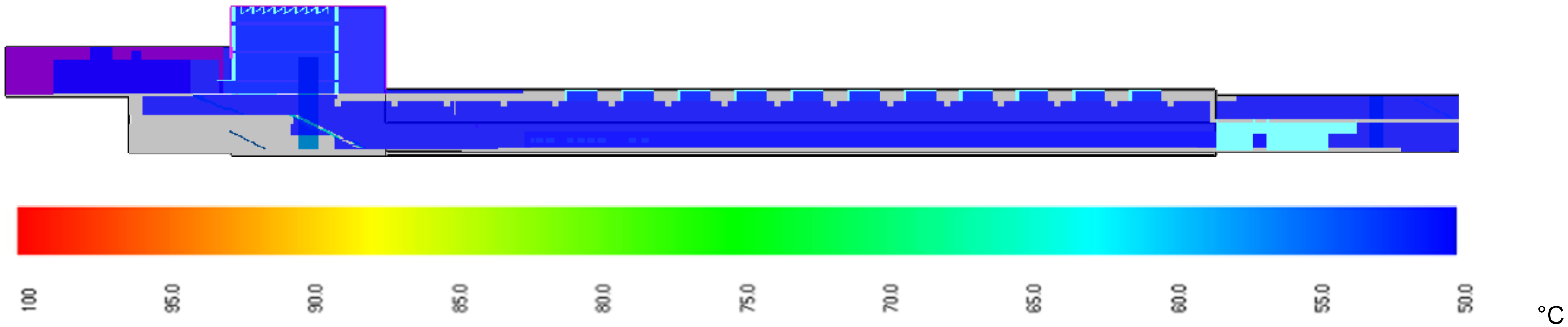
Therefore radiant heat can be discounted in the in $FED_{Thermal}$ calculation.

Radiant heat flux was also measure in front of the open train doors. Occupants can evacuate past the carriage of fire origin along the platform at least 3.0 m from the train door, where they are exposed to a maximum of 2.5 kW/m². Onset of pain occurs after being exposed for $t_p = (35/\dot{q}''_r)^{1.33} = (35/2.5)^{1.33} = 33$ seconds. Occupants will pass the exposure from the train door in a matter of seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 6 – T1-W 4 MW with 50% exhaust

<u>Convective Heat</u>



At 2.0 m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (1,200 seconds / 20 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*20$

$= 0.064$ (≤ 0.3 acceptable)

Fire Scenario 7 – T1-W 4 MW with no smoke curtains

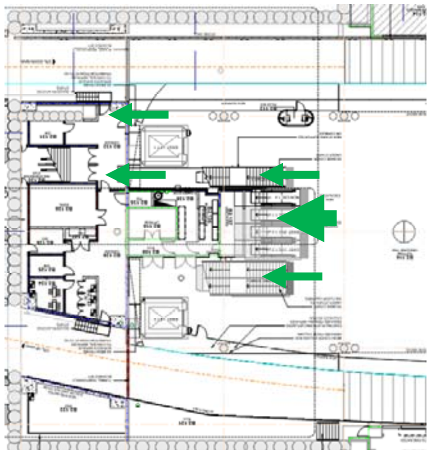
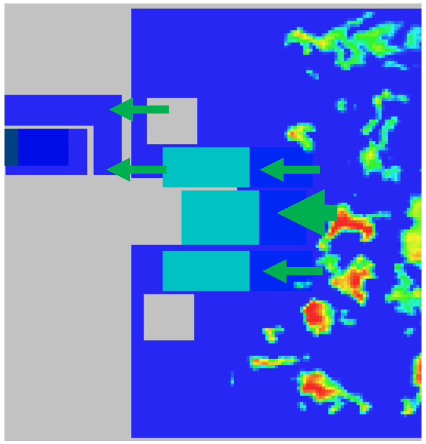
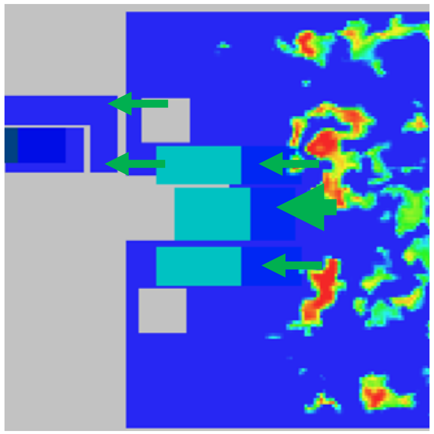
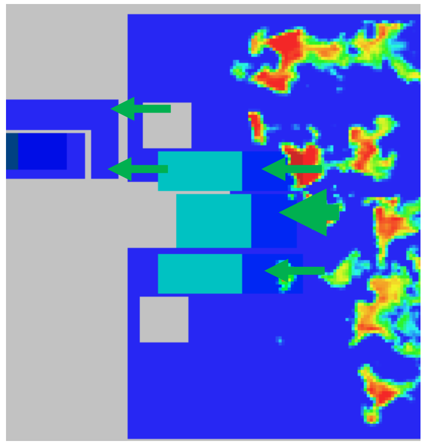
Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m

The period where the tenability criteria is exceeded is demonstrated by the 30 seconds prior to the nominated ASET, and the nominated ASET and 30 seconds after the nominated ASET.

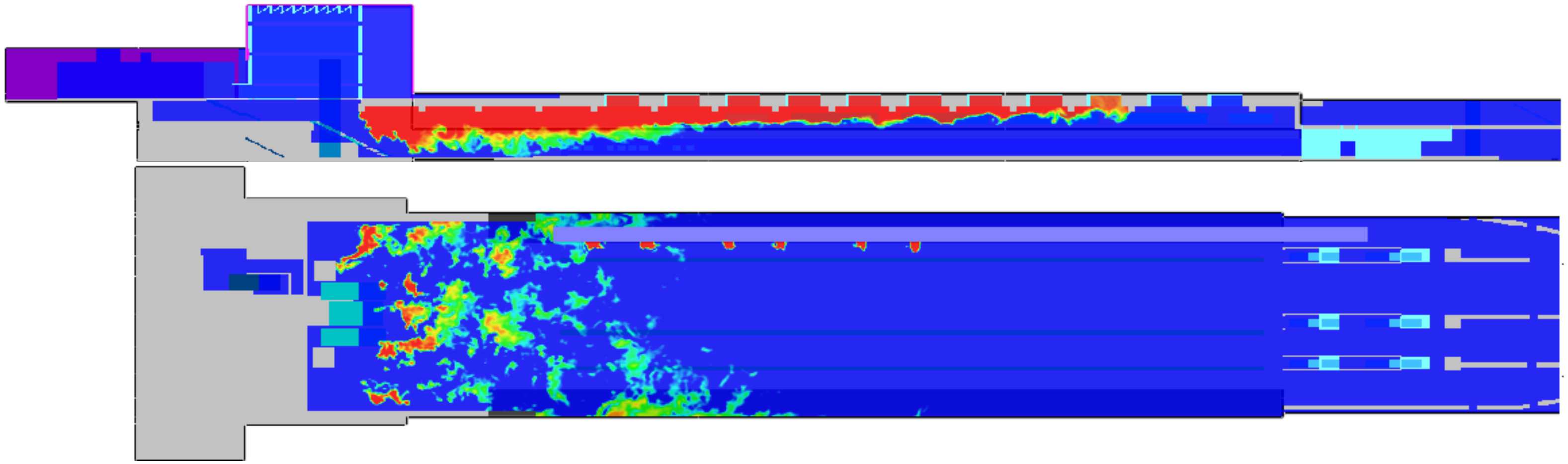
In this fire scenario the tenability criteria is considered to be exceeded on Platform Level (B2) at 396 seconds.

Tenability is considered to be maintained for > 852 seconds in all other areas.

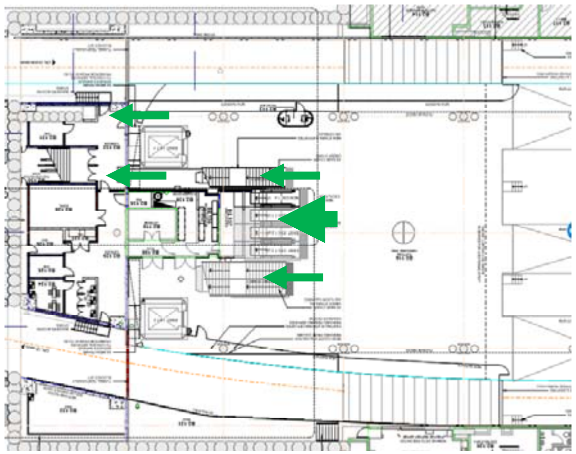
Britomart West Platform (B2)	T = 366 seconds	T = 396 seconds	T = 426 seconds
			

Fire Scenario 7 – T1-W 4 MW with no smoke curtains

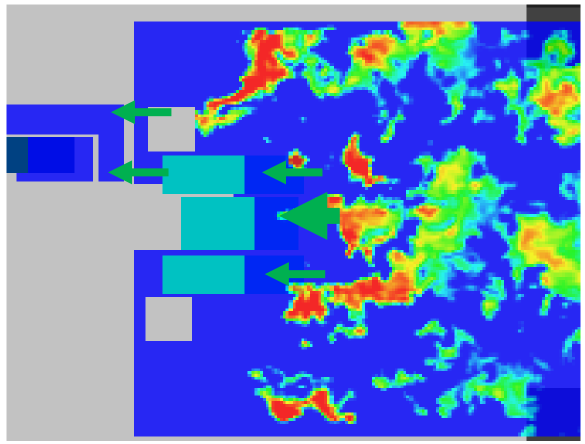
Platform Level: t = 852 seconds



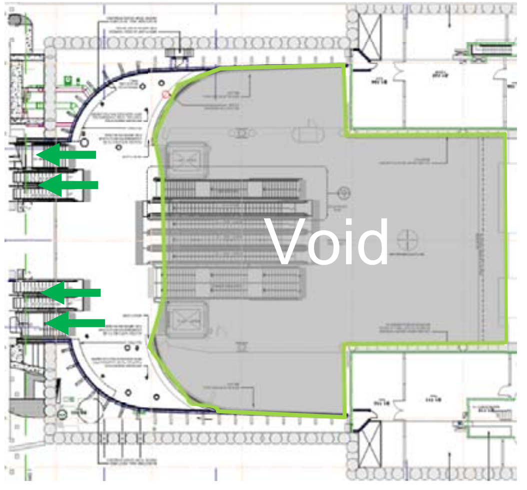
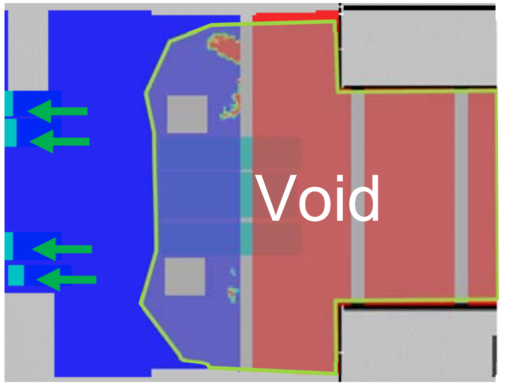
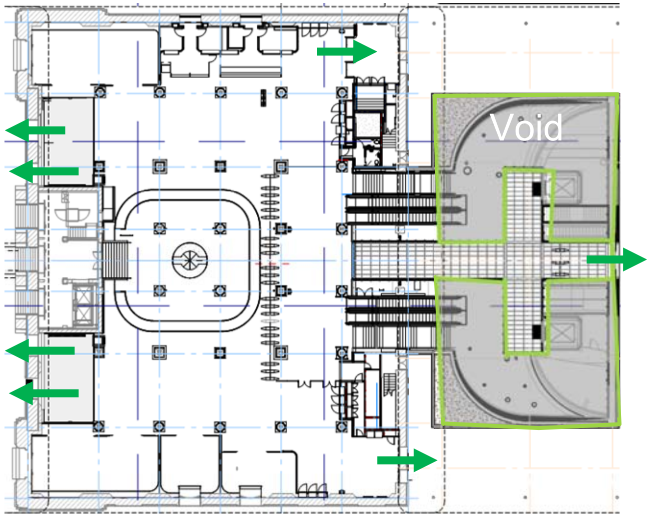
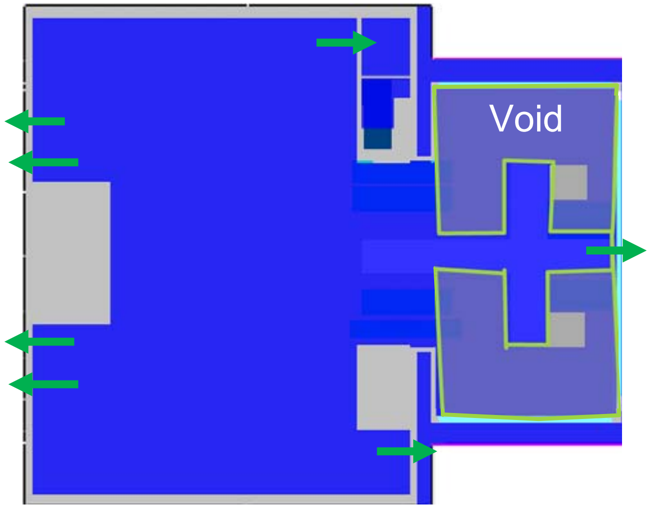
Britomart West Platform (B2)



Plan view at 2.0 m above B2 floor level

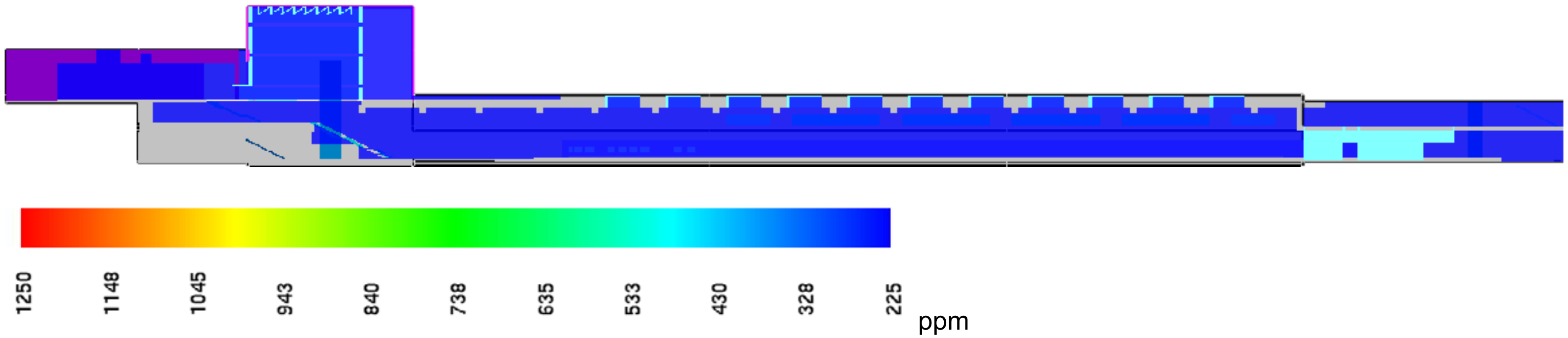


Fire Scenario 7 – T1-W 4 MW with no smoke curtains

Britomart West Concourse (B1)	Plan view at 2.0 m above B1 floor level
	
Glasshouse	Plan view at 2.0 m above Glasshouse floor level
	

Fire Scenario 7 – T1-W 4 MW with no smoke curtains

FED_{CO}



Tenability limit for FED_{CO} is exceeded when the FED_{CO} is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (852 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the model (14.2 minutes)

$FED_{CO} = (\varphi_{CO}/35{,}000)*\Delta t$

$FED_{CO} = (225/35{,}000)*14.2$

$= 0.091$ (≤ 0.3 acceptable).

Fire Scenario 7 – T1-W 4 MW with no smoke curtains

$FED_{Thermal}$

Tenability limit for $FED_{Thermal}$ is exceeded when the $FED_{Thermal}$ is greater than 0.3

$FED_{Thermal}$ is a function of both radiant heat and convective heat. Note the radiant heat flux term is set at zero where the radiant heat flux is less than 2.5 kW/m²

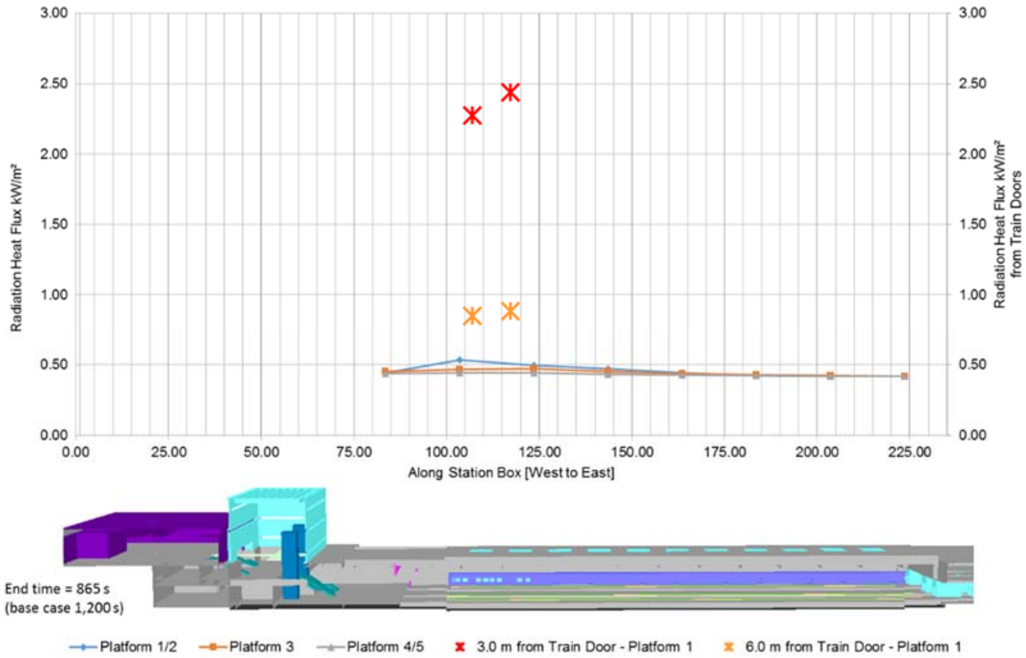
<u>Radiant Heat</u>

The upper layer temperature is less than 200°C indicating the radiant heat flux is less than 2.5 kW/m². Furthermore at 1.5 m above platform level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² at the conclusion of the model (852 seconds). Note 0.42 kW/m² is the background radiant heat flux within the model.

Performance Requirements of C3.8 are achieved as the radiation flux at 1.5 m above the floor does not exceed 4.5 kW/m² at the conclusion of the modelled fire scenario.

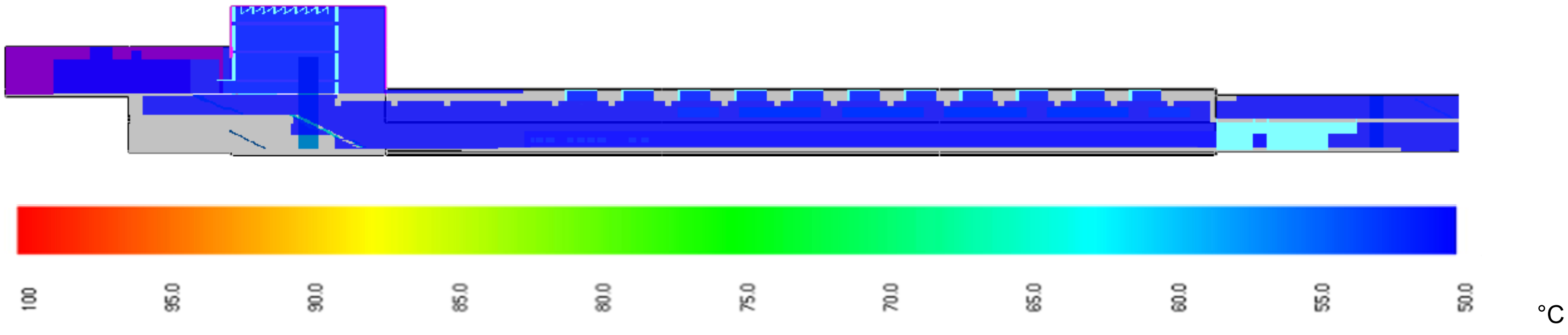
Therefore radiant heat can be discounted in the in $FED_{Thermal}$ calculation.

Radiant heat flux was also measure in front of the open train doors. Occupants can evacuate past the carriage of fire origin along the platform at least 3.0 m from the train door, where they are exposed to a maximum of 2.4 kW/m². Onset of pain occurs after being exposed for $t_p = (35/\dot{q}''_r)^{1.33} = (35/2.4)^{1.33} = 35$ seconds. Occupants will pass the exposure from the train door in a matter of seconds. However, egress calculations have assumed that occupants do not pass the incident location and will disperse in either direction (east or west) along the incident platform away from the fire location.



Fire Scenario 7 – T1-W 4 MW with no smoke curtains

Convective Heat



At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the model (852 seconds / 14 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8}x\ 50^{-3.61}])*14.2$

$= 0.045\ (\leq 0.3$ acceptable)

Required Safe Egress Time

The Required Safe Egress Time (RSET) can be expressed in the following equation:

RSET = (t_d + t_n + t_{pre}) + (t_{trav} or t_{flow})

Each of these components are individually discussed and assessed below.

Alarm Time (t_d + t_n) and Pre-movement Time

As per Temporary Works, occupants are notified of a fire and begin moving within 60 seconds of the train reaching the platform.

Alarm Time and Pre-movement Time – 60 seconds

Travel Time (t_{trav} or t_{flow})

Evacuation times from the station will be assessed by spreadsheet calculation based on the methodology, travel speeds, and flow parameters promulgated by NFPA 130.

The total population within the station Permanent Works remains at 2,600 persons, as the station remains a terminus with no additional services, until commissioning of the CRL lines which will be addressed in a future permit application. The population has been divided in line with the Stacey Agnew assessment, which is proportional with respect to area of the platforms. As such:

- Platform 1/2 933 occupants
- Platform 3 736 occupants
- Platform 4/5 933 occupants

The nodes of the evacuation calculation are the exits/ pinch points and are outline below:

From Britomart East (no change during the Enabling Works).

Basement 2 to Basement 1

			Width (m)		Capacity [p/min]
		Platform 1/2			
	down	Esc 2.1	1.30		72.4
		Stair 5	1.50		83.3
		Sub Total	**2.80**	C_{E1A}	**155.6**
		Platform 3			
	down	Esc 3.1	1.30		72.4
		Stair 6	1.50		83.3
		Sub Total	**2.80**	C_{E1B}	**155.6**
		Platform 4/5			
	down	Esc 4.1	1.30		72.4
		Stair 7	1.50		83.3
		Sub Total	**2.80**	C_{E1C}	**155.6**

Basement 1 to Ground

Gateline	*Fare barrier*		*0.50*	no.	8	400.0
	Emergency gate		*1.64*			134.6
					C_{E2}	**534.6**
	down	Esc 7.1	1.50			75.0
	up	Esc 8.1	1.50			75.0
		Stair 12/13	2.80			155.4
		Total	**5.80**		C_{E3}	**305.4**

Similarly for Britomart West

West End Basement 2 to Basement 1			**Width (m)**		**Capacity [p/min]**
		Exisiting Stair 2	2.90		161.0
	up	Esc 1.3	1.00		75.0
	down	Esc 1.2	1.00		55.5
	down	Esc 1.1	1.00		55.5
	out	Esc 1.4	1.00		0.0
		New Stair 1	1.70		94.4
		Lobby & stair doors	2.20		180.2
		Fire Intervention Sta	3.20		**177.6**
		Total	**10.80**	C_{P1}	**618.9**

West End Basement 1 to Ground			Width (m)		Capacity [p/min]
		Existing Stair 11	2.20		122.1
	up	Esc 6.2	1.00		75.0
	down	Esc 6.1	1.00		55.5
	out	Esc 5.1	1.00		0.0
	down	Esc 5.2	1.00		55.5
		New Stair 10	2.00		111.0
		Total	**8.20**	C_{P2}	**419.1**

CPO Fare Gates

	Width (m)			Capacity [p/min]
Fare barrier	*0.50*	no.	16	800
Accessible gate	*1.00*	no.	2	120
Emergency gate	*2.12*			173.6
			C_{P3}	**1093.6**

Glasshouse Fare Gates

	Width (m)			Capacity [p/min]
Fare barrier	*0.50*	no.	0	0
Accessible gate	*1.00*	no.	2	120
Emergency gate/s	*0.00*			0.0
			C_{P3A}	**120.0**

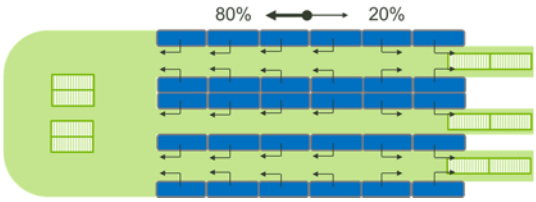
Ground Floor Exits

		Width (m)		Capacity [p/min]
CPO	Station Entry A	2.30		188.4
	Station Entry B	2.30		188.4
	Station Entry C	2.30		188.4
	Station Entry D	2.30		188.4
	Station Entry E	1.50		122.9
	Station Entry F	1.50		122.9
	Station Entry G	1.50		122.9
	Station Entry H	1.50		122.9
	~~Door to vesibule~~	~~2.60~~		~~212.94~~
	~~Retail 800~~	~~3.00~~		~~245.7~~
	~~Retail 805~~	~~3.00~~		~~245.7~~
	Total	**15.20**	C_{P4}	**1244.9**
Glasshouse	Glasshouse (Station Entry I)	3.60		0.0
			C_{P4A}	**0.0**

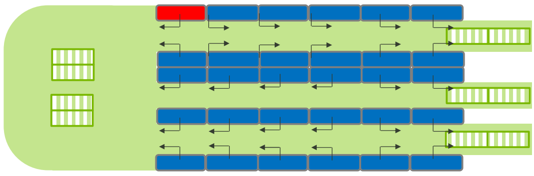
A number of egress scenarios have been considered. As a base case, the population is split proportionally with respect to available egress width. So, from each platform the occupant population evacuates 80 % to the West and 20 % to the East.

There are then fire scenario specific cases which consider where occupants can/will not evacuate past the carriage of fire origin. So, on the fire platform occupants evacuate one carriage to the fire affected end and five carriages to the non-fire affected end, i.e. 17% to 83% split.

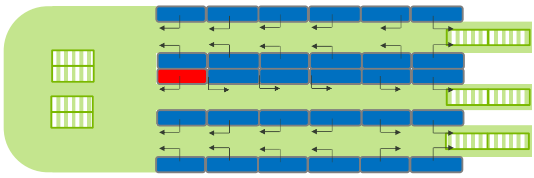
As illustrated below:



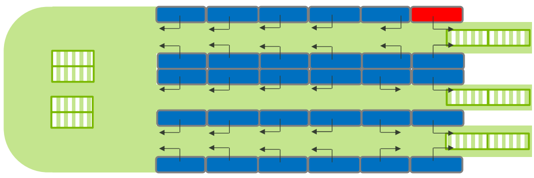
Case 1: Base Case



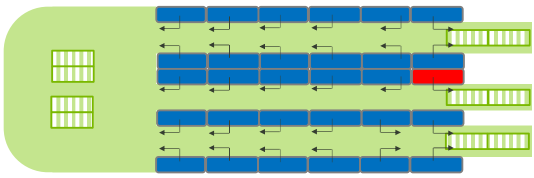
Case 2: T1 west



Case 3: T3 west



Case 4: T1 east



Case 5: T3 east

Due to the consolidation of the fire scenarios Case 3 and Case 5 are not relevant to the Permanent Works assessment.

The egress calculation considers the time to clear the platform and the time to clear the station onto street level. However, it is noted that once occupants have cleared the Platform at Britomart East they are effectively separated from the effects of fire. There are enclosures around the stairs/ escalators and make-up air being drawn down through the stair/escalator openings, which effectively keeps the escape route clear of smoke in a fire event.

From Britomart West, as the concourse and Glasshouse are open to the station below, time to clear the station has also been calculated.

The clearance times are summarised below.

Case	Exit Path Blocked by Fire	East/West Split			Clearance Time [seconds]			
		P1/2	P3	P4/5	Platform East	Station East	Platform West	Station West
1	none	20:80	20:80	20:80	72	258	283	489
2	T1 west	83:17	20:80	20:80	300	458	239	440
4	T1 east	17:83	21:79	20:80	72*	252	287	493

** It is expected that the occupants within immediate proximity of the fire will being evacuating immediately without an alarm time or pre-movement time, therefore in the event of a fire in Carriage 6 the time to clear the platform closest to the fire via the Britomart East exits is: Platform 1/2 in 60 seconds.*

A full worked example for the base case is contained within Appendix K.

RSET

The RSET from each end of Britomart Station includes an ***additional 60 seconds*** of Alarm Time and Pre-movement Time.

Case	Exit Path Blocked by Fire	East/West Split			Clearance Time [seconds] (***1.5 x RSET***)			
		P1/2	P3	P4/5	Platform East	Station East	Platform West	Station West
1	none	20:80	20:80	20:80	132 *198*	318 *447*	343 *515*	549 *823*
2	T1 west	83:17	20:80	20:80	360 *540*	518 *778*	299 *448*	500 *750*
4	T1 east*	17:83	21:79	20:80	132 *198*	312 *468*	347 *521*	553 *829*

* *It is expected that the occupants within immediate proximity of the fire will being evacuating immediately without an alarm time or pre-movement time, therefore in the event of a fire in Carriage 6 the time to clear the platform closest to the fire via the Britomart East exits is: Platform 1/2 in 57 seconds.*

ASET vs RSET Summary

Base case fire scenarios will be compared against both the base case egress scenarios 1.5 x Case 1, and the relevant sensitivity case.

Fire Scenario		Egress scenario	ASET vs RSET *(1.5 x RSET)*				ASET ≥ RSET	Comments
			Platform East	Station East	Platform West	Station West		
1	Base Case - T1C1 4MW	1.5xCase 1	*1200 vs 198*	*1200 vs 447*	*1200 vs 515*	*1200 vs 823*	*Yes*	
		Case 2	360	518	299	500		
3	Base Case - T1C6 4MW	1.5xCase 1	*972 vs 198*	*972 vs 447*	*972 vs 515*	*972 vs 823*	*Yes*	Tenability maintained for duration of model, except Britomart East Platform 1/2 due to the fire location being directly adjacent to exits. It is expected that the occupants within immediate proximity of the Britomart East exits on platform 1/2 including occupants in Carriage 6 will utilise the Britomart East exits during the growth phase of the fire. This is in line with Egress Case 4, which calculates the clearance time of Platform 1/2 at Britomart East to be 57 seconds. It is expected that in the immediate vicinity of the fire occupants will begin evacuating immediately i.e. no alarm or pre-movement time.
		Case 4	132	312	347	553		
5	Sensitivity - T1C1 10 MW	Case 1	*1200 vs* 132	*1200 vs* 318	690 *vs* 343	*1200 vs* 549	Yes	Britomart West tenability within close proximity of the exits is maintained for the duration of the simulation. Occupants are able to queue within the fire lobby which is separated from the platform before evacuating via the fire intervention stair.
		Case 2	360	518	299	500		
6	Redundancy T1C1 50%	Case 1	*1200 vs* 132	*1200 vs* 318	630 *vs* 343	*1200 vs* 549	Yes	Britomart West tenability within close proximity of the exits is maintained for the duration of the simulation. Occupants are able to queue within the fire lobby which is separated from the platform before evacuating via the fire intervention stair.
		Case 2	360	518	299	500		
7	Redundancy T1C1 no SC	Case 1	*852 vs* 132	*852 vs* 318	*396 vs* 343	*852 vs* 549	*Yes*	Britomart West tenability within close proximity of the exits is maintained for the duration of the simulation Occupants are able to queue within the fire lobby which is separated from the platform before evacuating via the fire intervention stair.
		Case 2	360	518	299	500		

In the event the RSET exceeds the ASET at a given exit, if tenability is maintained for the duration of the model (indefinitely) along alternate egress paths, occupants are able to travel away from the effects of fire and egress toward the other end of the station. Staff are to be trained to supervise evacuations and can direct occupants to the most appropriate exit in any give fire scenario.

System Failures

This assessment of system failures has considered the following system failure scenarios.

System	Description	Assessment	Comment
Smoke Management	Reliance on any mechanical or electrical component for activation	Quantitative	Refer Fire Scenario 6 and Fire Scenario 7.
Fire Closures	Fire and/or smoke control doors or similar fire closures. Where installed and maintained in accordance with NZ or international standard the system is considered sufficiently reliable.	Qualitative	BOH and FOH are fire separated. There are no hold open devices between these areas and due to security requirements to keep the public out of BOH areas these doors will be constantly monitored to ensure fire doors are closed.
Fire sprinkler system	Fire sprinkler systems system failure is considered highly unlikely as supported by many assumptions in the NZBC C/AS documentation which permit numerous concessions where fire sprinkler systems are installed. FEDG notes that, in New Zealand, fire sprinkler systems have a very good reliability record.	N/A	Platforms, the Britomart West concourse and Glasshouse are not fire sprinkler protected. BOH areas where fire sprinklers are installed will be installed and maintained in accordance to NZ Standards.
Fire detection & alarm system	Automatic fire alarms installed to a recognised national or international Standard, can be considered to be sufficiently reliable. This is supported by many assumptions in the NZBC C/AS documentation including the allowance to increase the length of escape routes where fire and detection systems are installed.	Qualitative	Detection is only provided at high level above the station and in BOH areas where there are no sprinklers. All systems are to be installed in accordance to NZ Standards. Further redundancy is provided by: The alternative means by which fire can be detected is as follows: • Visual detection by building occupants. • Visual detection by staff monitoring the CCTV • Automatic heat detection using the sprinklers as thermal detectors. The alternative means by which a fire alarm may be raised and

System	Description	Assessment	Comment
			evacuation initiated is as follows: • Staff / occupants. • Staff manually initiating the occupant warning system or making announcements over the PA system.
Exit Blocked	An escape route may be blocked due to proximity of the fire source	Qualitative	Multiple exits provided. Tenable conditions provided for greater than 1.5 x RSET allows additional time for occupant egress in the event an exit is blocked. Egress scenarios also consider an exit blocked by fire.

Fire Fighting Operations

In all fire scenarios the modelling demonstrated that along the platforms the radiant heat flux 1.5 m above floor level, at the end of the simulated time, is well under the 4.5 kW/m² limit required per Performance Requirement C3.8.

Furthermore, the modelling demonstrates that visibility is maintained above 10 m from at least the non-fire end of the platform for the duration of the model for all fire scenarios. Where visibility is greater than 10 m it can be reasonably assumed that that area is relatively smoke-free and beneath the smoke layer.

The modelled times are sufficient to encompass fire service response times, which according to the national service delivery guidelines (2015 Annual Report, NZFS Commission) aim to have a response time to structure fires of 8 minutes 90% of the time for career stations.

The two nearest fire stations are:

Fire Station	Address	Distance*
Auckland City Station	40 Pitt Street, Auckland, 1010	2.1 km
Ponsonby	182 Ponsonby Road, Ponsonby, 1011	3.0 km

* Route distance calculated by google maps ref. map data © 2015 Google

Our shortest simulation time is 660 seconds (11 minutes) for a redundancy case, however the base case fire scenarios (up to 20 minutes) show conditions have reached steady-state with suitable conditions for fire fighter intervention.

The NZFS can access the platforms from either end of the station and therefore can approach a train or platform fire event from the non-fire side. Modelling has demonstrated that acceptable conditions are maintained in line with the provisions outlined in NZBC C3.8.

Furthermore, during the Permanent Works phase there is a Fire Intervention Station from street level directly to the platform. The fire lobby at platform level contains a fire hydrant from which the fire service can set-up remote from the effects of fire.

Comparative Assessment

The previous consent documents (Stacey Agnew, Britomart Station Fire Life Safety Review 3586-R01, 26 August 2011) included modelling results of fire scenarios within the station under existing (pre-Enabling) conditions. As there were diesel trains in operation within the station, the design fire was a 52 MW ultra-fast fire (i.e., the peak HRR was achieved within 540 seconds). Stacey Agnew modelling considered fire scenarios at locations along track 3: T3-W, T3-E and T3 middle.

The Permanent Works modelling did not include fire scenarios on Track 3 as Track 1 was deemed to result in more challenging conditions. As such, T1-W and T1-E scenarios have been compared to the corresponding Track 3 scenarios carried out by Stacey Agnes to demonstrate that there is a relative improvement of the conditions within Britomart Station in the event of a fire. The evident improvements are attributable in large part to the reduction in design fire due to the cessation of diesel train services prior to the onset of the Britomart Temporary Works.

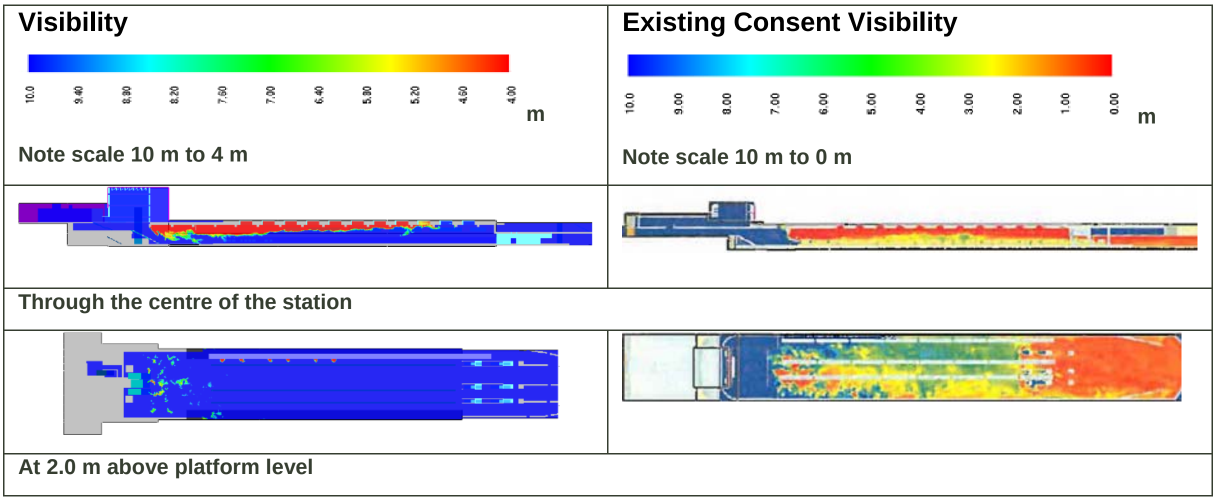


Figure 10: T = 600 s, Base Case train fire located T1-W compared with existing conditions T3 - W

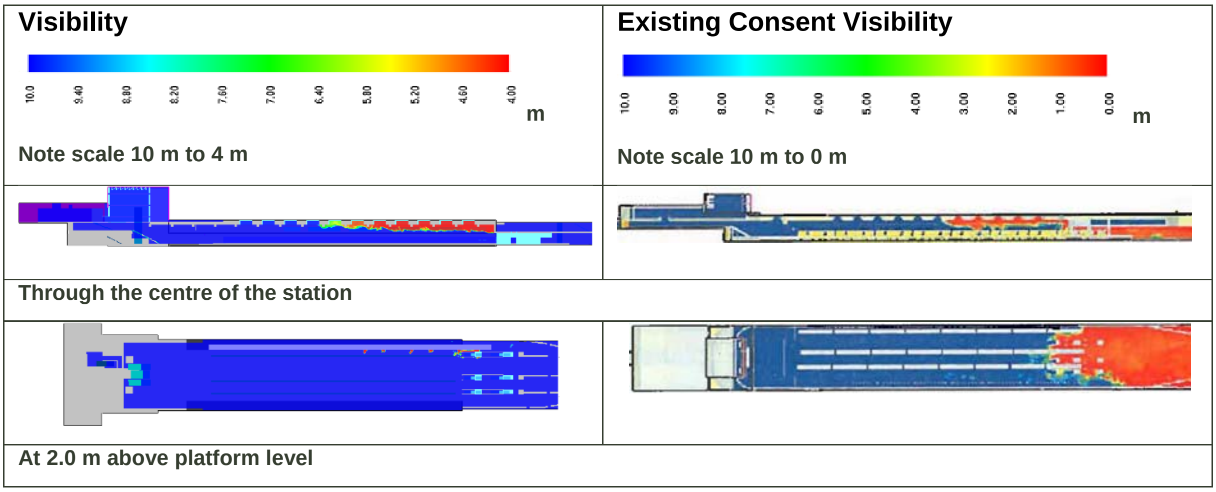


Figure 11: T = 600 s, Base Case train fire located T1-E compared with existing conditions T3 - E

Conclusions

Britomart Station under Permanent Works conditions satisfies the Performance Requirements C3.8, C3.9, C4.3 and C4.4 of the NZBC.

Appendix F
CPO Assessment

Analysis

This section presents a quantitative timeline assessment of the Available Safe Egress Time (ASET) compared with the Required Safe Egress Time (RSET) for occupants within the CPO building.

In isolation, the CPO complies with C/AS4 requirements. The analysis has therefore been conducted for completeness as the CPO is connected to the Britomart Transport Centre. As such, the CPO is only being assessed as a base case, without consideration of system failures.

Available Safe Egress Time

The ASET times have been calculated by undertaking CFD modelling of the aerodynamically interconnected parts of the building. The input times for various parts of these models are summarised below.

Design Fire and Fire Scenarios

The fire scenarios and design fires have been agreed with the stakeholders as part of the FEB process.

Table 74: Design Fire Parameters

Design Fire Parameters	
Design Fire ID	Sprinkler Controlled Fast t^2 Fire
Fire growth rate	Fast t^2 fire
Sprinkler activation	Calculated via FPETool RTI - 50 Activation temperature - 68 °C r_{spk} – 3.0 m Ceiling height – 6.3 m T_{act} = 194 seconds
HRR	1.7 MW at sprinkler activation 3.0 MW at steady state*
Comment	Sprinkler activation verified as conservative with a thermal device in FDS. Due to conservatism introduced into FPETool calculation by using a higher ceiling height 6.3 m compared with 5.7 m. Due to information available at FEB stage celing height based on highest point (i.e., top of skylight).

*Assumes control achieved within 60 seconds of sprinkler activation as described in the FEB.

This design fire is considered to be conservative, considering that it is likely that once sprinklers activate they would typically reduce the fire size and possibly suppress if not extinguish the fire over time. The assumed heat release rate curve for the base case is depicted as follows:

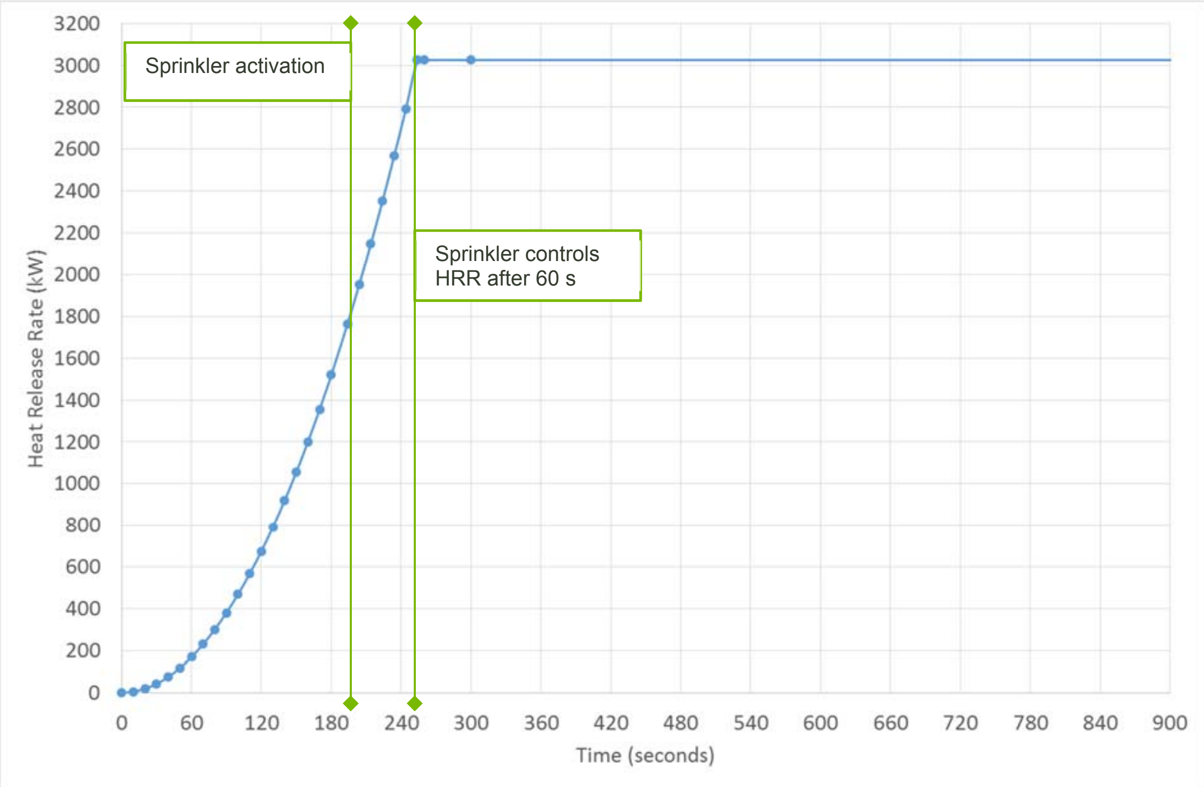


Figure 10: CPO Design Fire – Sprinkler Controlled Fast t² Fire

From the design fire, the following fire scenario has been considered:

Table 85: Fire Scenarios

Fire Scenario	Location	Design Fire	Case	Comments
1	CPO circulation area	Sprinkler Controlled Fast t² Fire	Base Case	

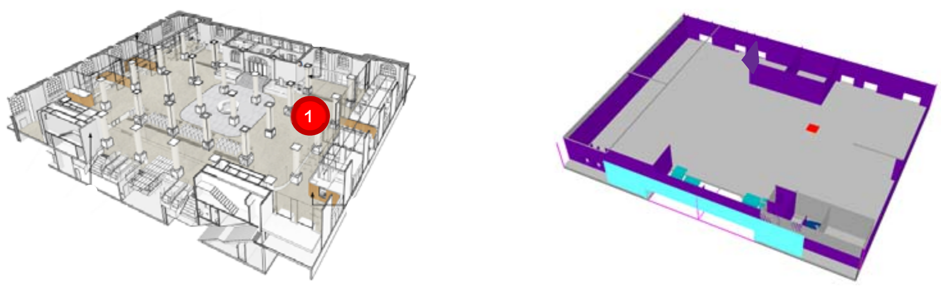


Figure 11: CPO – Isometric building model and FDS model geometry indicating fire location

FDS Parameters

Inputs		Comments
Model geometry	As per drawings	CPO with horizontal opening into the glasshouse
Grid resolution (4 < D*/δx < 16)	0.10 ~ 0.40	Based on Q = 3.0 MW
Mesh size	0.2m x 0.2m x 0.2m	
Simulation time	1,092 seconds	
Ventilation / Makeup air	Makeup air: Station Entry A, B, C, D, G and H Open boundaries by way of the Glasshouse also provide make up air	
Fire Safety Systems	It is noted that sprinklers will not be included within the model(s); design fires will simply be modelled to maintain a steady state HRR after the predicted time of sprinkler activation	
Fuel type	Polyurethane, $C_{6.3}H_{7.1}P_{2.1}N_{1}$	
Soot yield	0.07 kg_{soot} / kg_{fuel}	
CO yield rate	0.04 g/g	Assumes well-ventilated combustion conditions
Visibility Factor	2.0	
Heat release rate per unit area (HRRPUA)	HRRPUA = 550 kW/m^2	This is the value for shops/retail occupancies; refer Table 10.3 of CIBSE Guide E.
Heat Flux Devices	20 off, 2.0 m above floor level 10.0 m x 10.0 m grid pattern	

Results

The ASET was determined to be 420 seconds.

For a complete set of the results refer Appendix J.

CPO Fire

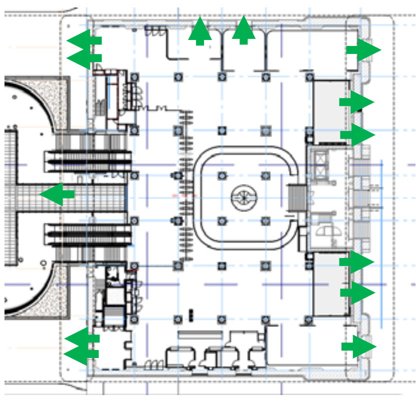
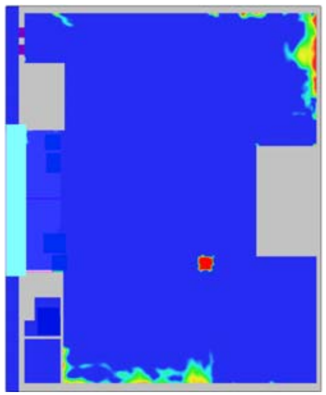
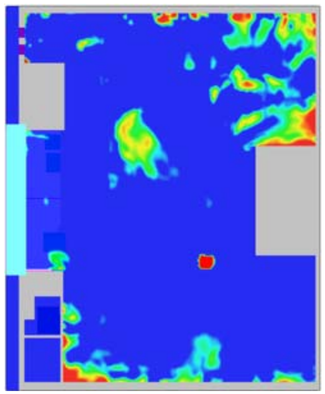
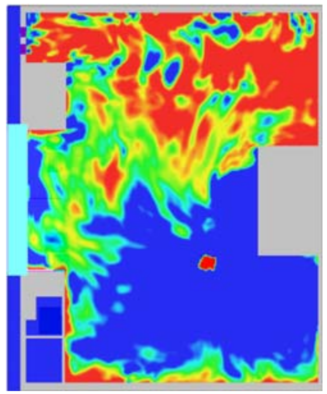
Visibility

Tenability limit for visibility is exceeded when the visibility is less than 10 m.

The period where the tenability criteria is exceeded is demonstrated by the 30 seconds prior to the nominated ASET, the nominated ASET, and 30 seconds after the nominated ASET.

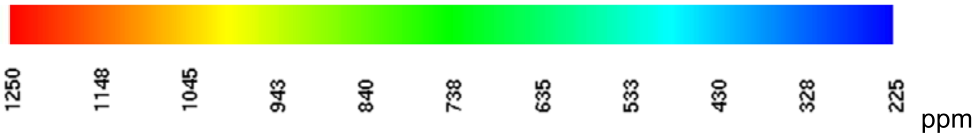
In the CPO fire scenario the tenability is considered to be 420 seconds.

- At 390 seconds the majority of the floor area is tenable.
- At 420 seconds there are still 4 exits which provide tenable conditions; in addition, occupants within the CPO are also able to exit via the Glasshouse as the ticket gates automatically open on fire alarm.
- At 450 seconds only the area around two of the exits remains tenable.

Exits	t = 390 seconds	t = 420 seconds	t = 450 seconds
			

CPO Fire

FED$_{CO}$



Tenability limit for FED$_{CO}$ is exceeded when the FED$_{CO}$ is greater than 0.3

At 2.0m above floor level the CO concentration up to ASET (420 seconds) does not exceed 225 ppm.

As a simplified and conservative calculation the CO concentration is taken as 225 ppm for the duration of the ASET (7 minutes)

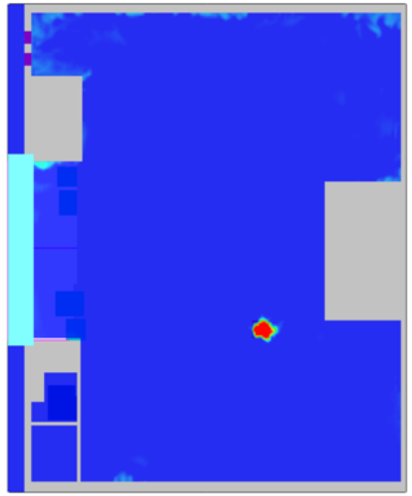
FED$_{CO}$ = (φ_{CO}/35,000)*Δt

FED$_{CO}$ = (225/35,000)*7

= 0.045 ($\leq$ 0.3 acceptable)

Note: At the conclusion of the model (1,092 seconds) the CO concentration is between 430 ppm and 533 ppm. Even if the FED$_{CO}$ is calculated utilizing the peak CO concentration of 533ppm for the duration (1092s) of the model the FED$_{CO}$ =0.28 ($\leq$ 0.3, therefore acceptable).

T = 420 seconds



CPO Fire

FED$_{Thermal}$

Tenability limit for FED$_{Thermal}$ is exceeded when the FED$_{Thermal}$ is greater than 0.3

FED$_{Thermal}$ is a function of both radiant heat and convective heat.

Radiant Heat

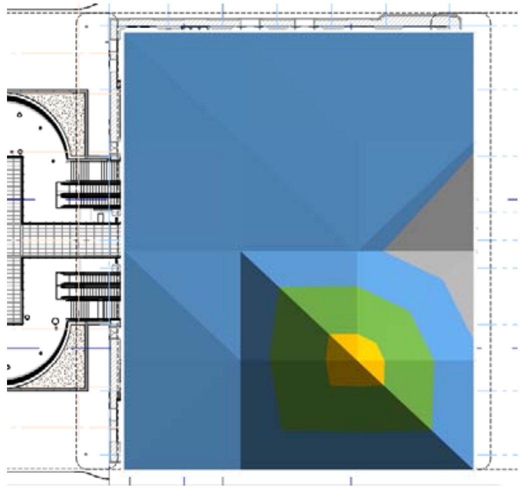
■ 0.40-0.60 ■ 0.60-0.80 ■ 0.80-1.00 ■ 1.00-1.20

kW/m²

At 2.0m above floor level areas remote from the fire, the radiant heat flux is less than 2.5 kW/m² for both the ASET and at the conclusion of the model (1,092 seconds). Note: 0.42 kW/m² is the background radiant heat flux within the model.

Therefore radiant heat can be discounted in the in FED$_{Thermal}$ calculation.

This also demonstrates the Performance Requirements of C3.8 are achieved as the radiation flux 1.5 m above the floor (2.0 m) does not exceed 4.5 kW/m² at the conclusion of the modelled scenario.



CPO Fire

Convective Heat

At 2.0m above floor level the temperature for the duration of the model does not exceed 50°C.

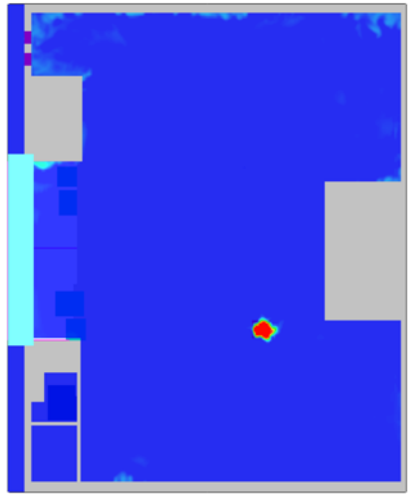
As a simplified and conservative calculation the temperature is taken as 50°C for the duration of the ASET (420 seconds / 7 minutes)

$FED_{Thermal} = (1/t_{Iconv})*\Delta t$

$FED_{Thermal} = (1/[4.1x10^{8} x\ 50^{-3.61}])*7$

$= 0.022$ ($\leq$ 0.3 acceptable)

Note: The $FED_{Thermal}$ is calculated with 50°C for the duration of the model (1092s) the $FED_{Thermal}$ =0.064 ($\leq$ 0.3, therefore acceptable).



Required Safe Egress Time

The Required Safe Egress Time (RSET) can be expressed in the following equation:

RSET = (t_d + t_n + t_{pre}) + (t_{trav} or t_{flow})

Each of these components are individually discussed and assessed below.

Alarm Time (t_d + t_n)

For the assessment the alarm time has been based on visual detection due to the highly controlled nature of the space. Whenever the building is occupied there will be station staff and security staff manning the area, in addition there is CCTV coverage which is monitored by the MC. The base case alarm time is considered to be via manual activation, this conservatively estimated to be:

Alarm Time – 60 seconds

By 60 seconds the smoke plume is pronounced, and the smoke plume is extending along the ceiling, therefore the fire would be clearly visible to occupants as the majority of the CPO is open plan, as shown below in Figure 12Figure 11.

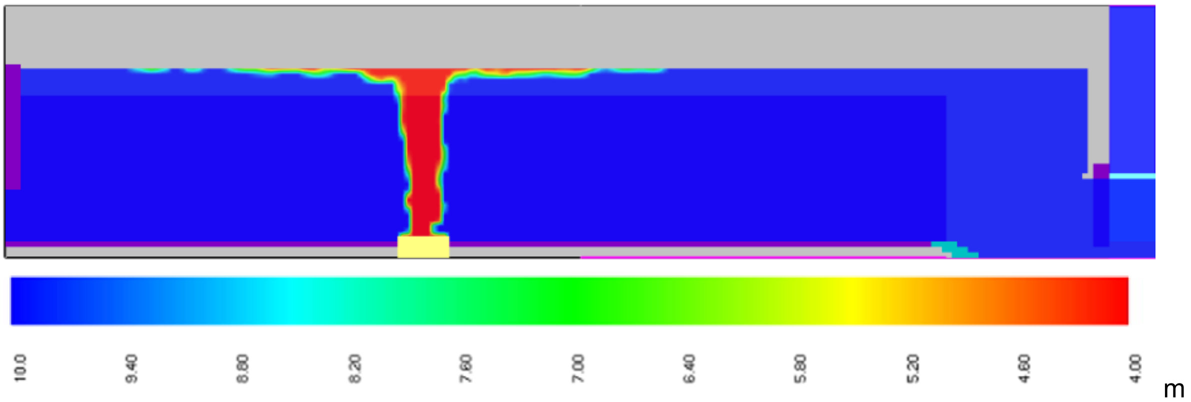


Figure 12: Cross Section of the CPO, visibility (m) at 60 seconds

In lieu of Fire Scenario Sensitive Cases, the sensitivity of the RSET has been investigated as the CPO building has multiple methods of triggering an alarm and initiating evacuation, the following have been considered:

Table 96: CPO Alarm Times

Case	Alarm	Time [s]	Comment
1	VESDA	107 seconds	It is noted that the FEDG notes that aspirating smoke detection systems typically respond in less than 1 minute with a fire size between 10 -100 kW. The fire is 100 kW at 47 seconds + 60 second delay for SCR verification.
2	Later Manual Detection	120 seconds (refer Figure 13Figure 12)	Smoke layer 10 % ceiling height, occupants are likely to recognise a fire event even with no dedicated security staff or CCTV monitoring of the area, as per Jin, “Microeconomic Reform: Fire Regulation”, Building Regulation Review Task Force, Australia , 1991.
3	Sprinkler activation	194 seconds	

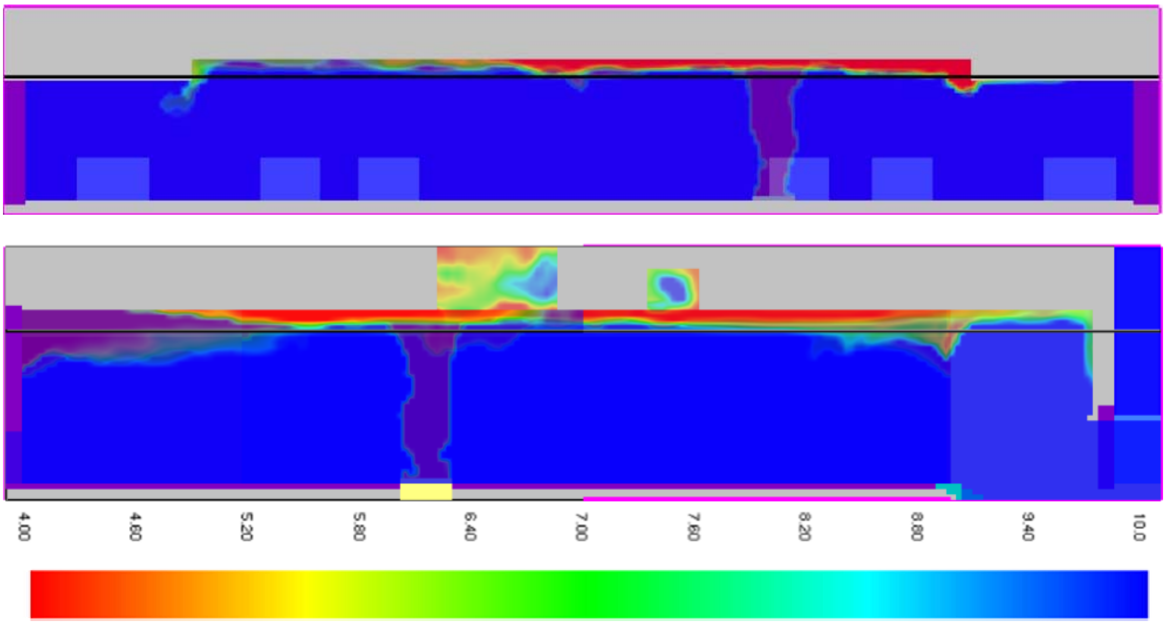


Figure 13: Cross Sections of the CPO, visibility (m) at 120 seconds (6.0 m above floor level indicated)

Pre-movement Time

As recommended in PD7974: Part 6, in a building where occupants are considered awake, alert and unfamiliar with the building, the pre-movement time in the enclosure of fire origin is 30 seconds.

The CPO Ground Level is a single enclosure, therefore:

Pre-movement Time – Up to 30s

Travel Time (t_{trav} or t_{flow})

There are multiple exits directly to outside, therefore there is no queuing at the exits expected and the travel time will be governed by movement time. Occupants from other parts of the station are not required to egress through the CPO in the event of a CPO fire. The evacuation mode and staff will direct occupants to Britomart East. As such, the occupant load considers persons within the CPO only.

Table 107: Summary of populations, exits and aggregate exit width.

Level	Estimated Maximum Population	Exits	Aggregate width	Travel Distance
Ground	948 Determined in the Section 112 review	Station Entry A, B, C, D Each 2.3 m Station Entry E, F, G and H each 1.5 m Retail Exits 4 off 2 x 1.7 m 2 x 2.0 m	22.6 m*	40 m to an exit Measured from drawings

* Conservative assumption as it does not consider occupant evacuation through the vestibule or via the glasshouse

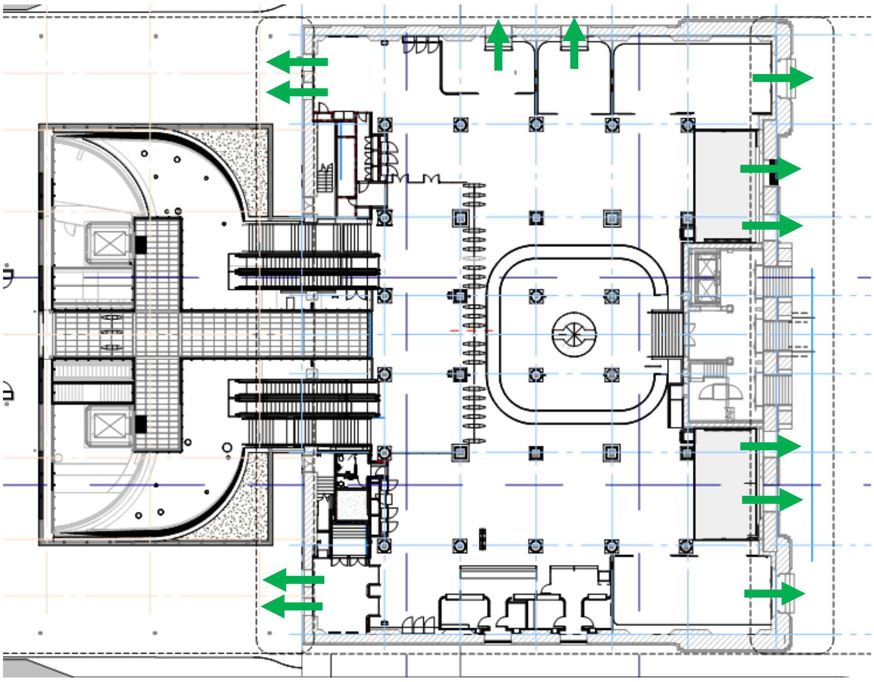


Figure 14: Egress from Glasshouse and CPO Post Enabling Works.

Travel Speed: S = k – akD

k 1.4

a 0.266

D person \m² occupant density of the space, determined in the Section 112 review, worst case: 1 m²/person

S = 1.03 m/s

Travel Time: $T_{trav} = L_{trav}/S$

L_{trav} Travel distance, 40 m

S 1.03 m/s

T_{trav} =39 seconds

Flow Rate: $F_c = (1\text{-}aD)kDW_e$

D occupant density near flow constriction (i.e., for doors, use 1.9 persons/m²)

W_e effective width of component being traversed in metres (Aggregate width - Boundary layer 12 doors @ 0.3m per door)

F_c = 25 persons/sec

Flow Time: T_{flow} = Persons/F_c

T_{flow} = 38 seconds

RSET

Scenario		Times [s]					
		$t_d + t_n$	t_{pre}	t_{trav}	t_{flow}	RSET	1.5 x RSET
Base case		60	30	39	~~38~~	***129***	***194***
Sensitivity	1 (VESDA)	107	30	39	-	***176***	-
	2 (Occupants)	120	30	39	-	***189***	-
	3 (Sprinkler)	194	30	39	-	***263***	-

ASET vs RSET Summary

Fire Scenario	Egress Scenario	ASET	RSET	ASET ≥ RSET
CPO Fire	Base (Staff)	420	194	Yes
	1 (VESDA)	420	176	Yes
	2 (Occupants)	420	189	Yes
	3 (Sprinklers)	420	263	Yes

System Failures

This assessment of system failures has considered the following system failure scenarios.

System	Description	Assessment	Comment
Smoke Management	Reliance on any mechanical or electrical component for activation	N/A	There are no smoke management systems within the CPO
Fire Closures	Fire and/or smoke control doors or similar fire closures. Where installed and maintained in accordance with NZ or international standard the system is considered sufficiently reliable.	Qualitative	The CPO Ground Level is a single firecell. Electrical/ Comms rooms that are fire separated from surrounding areas have fire/ smoke control doors. Given the function of these rooms the doors will be closed except when accessed to undertake works/ inspections. Any automatic closers and hold open devices will be designed and installed to an approved standard.

System	Description	Assessment	Comment
Fire sprinkler system	Fire sprinkler systems system failure is considered highly unlikely as supported by many assumptions in the NZBC C/AS documentation which permit numerous concessions where fire sprinkler systems are installed. FEDG notes that, in New Zealand, fire sprinkler systems have a very good reliability record.	N/A	Sprinklers are installed throughout the CPO in accordance to NZ Standards
Fire detection & alarm system	Automatic fire alarms installed to a recognised national or international Standard, can be considered to be sufficiently reliable. This is supported by many assumptions in the NZBC C/AS documentation including the allowance to increase the length of escape routes where fire and detection systems are installed.	Qualitative	In the event fire detection fails the area will either be contained to the area of fire origin or eventually activate the fire sprinkler system. Further redundancy is provided by: The alternative means by which fire can be detected is as follows: • Visual detection by building occupants. • Visual detection by staff monitoring the CCTV • Automatic heat detection using the sprinklers as thermal detectors. The alternative means by which a fire alarm may be raised and evacuation initiated is as follows: • Staff / occupants. • Staff manually initiating the occupant warning system or making announcements over the PA system.
Exit Blocked	An escape route may be blocked due to proximity of the fire source	Qualitative	Multiple exits provided, RSET conservatively discounted an exit as it did not include exits provided via the Glasshouse

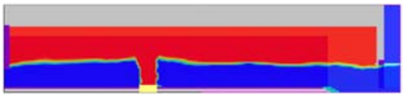
Fire Fighting Operations

The CPO itself is less than 5,000m² and is fire sprinkler protected; in isolation it is not required to meet the Performance Requirement C3.8. However, it is demonstrated that the radiant heat flux 2.0 m above floor level (more onerous than 1.5 m) is well under the 4.5 kW/m² limit required by Performance Requirement C3.8.

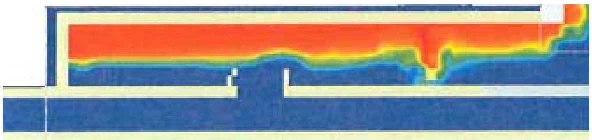
Comparative Assessment

The CPO in isolation is designed to meet C/AS4 requirements with consideration to Section 112. It is noted that the egress provisions continue to comply with C/AS4 requirements after the alterations, and the risk of fire remains the same, as the function and use of the area is not changing and the material linings will comply with C/AS4 requirements.

The previous consent documents (Stacey Agnew, Britomart Transport Centre Fire Life Safety Review 3586-R01, 26 August 2011) illustrates a CPO fire at 400 s. The design fire size is not specifically stated except that design fires between 1 MW and 5 MW were modelled within the concourse areas and the CPO.



Current CPO model



Stacey Agnew Model

Figure 15: CPO Post Enabling Works model comparison with previous existing consent model, visibility (m) at 400 seconds before alterations

Conclusions

The CPO design utilizing passive smoke control meets the Performance Requirements C3.8, C3.9, C4.3, C4.4, C4.5, C5.8, and C6.2 of the NZBC.

Appendix G
Temporary Entrance FDS Results

Fire Models

Fire Scenario	Run ID	Location	Design Fires	Case
Temp1	BritomartTemp	Retail Unit	Fast t^2 sprinkler controlled	Base Case
Temp2	BritomartTemp02	Centre of circulation area	Fast t^2 fuel controlled	Base Case

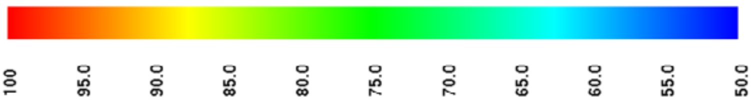
Legend

<u>Data bounds</u>

Visibility

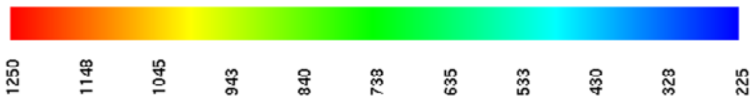
m

Temperature



°C

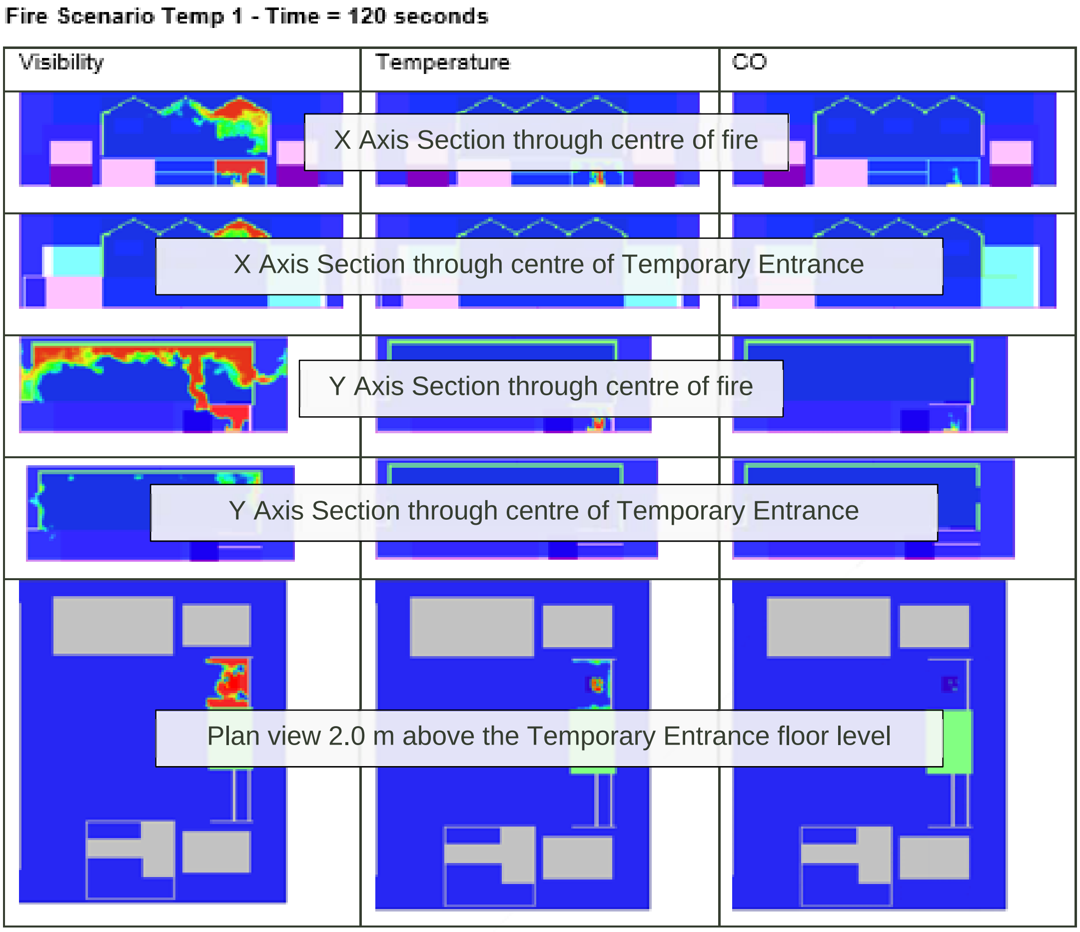
CO Concentration



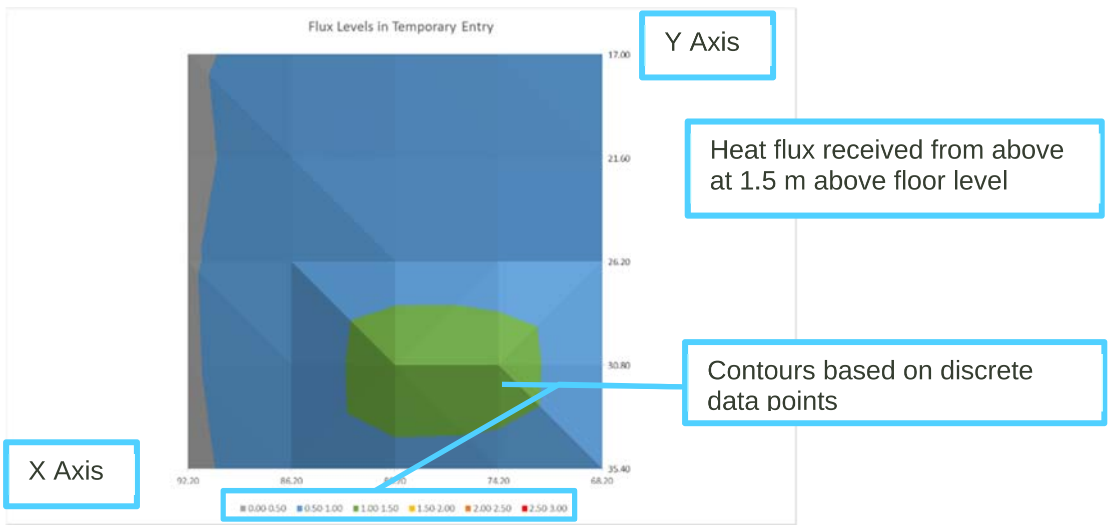
ppm

Views

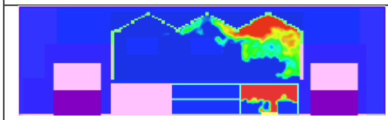
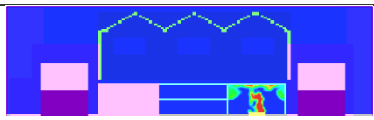
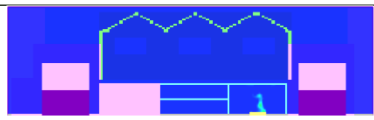
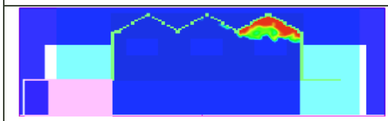
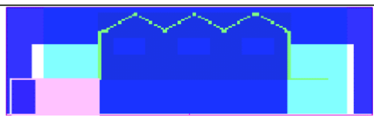
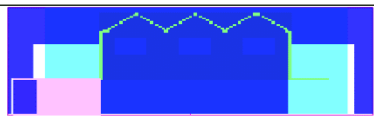
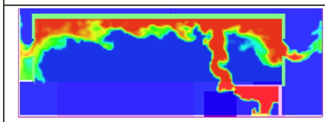
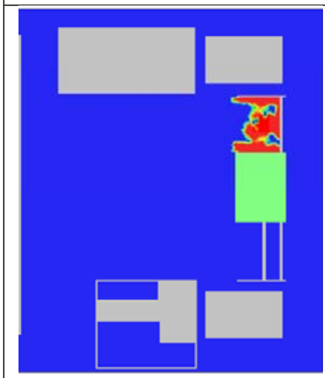
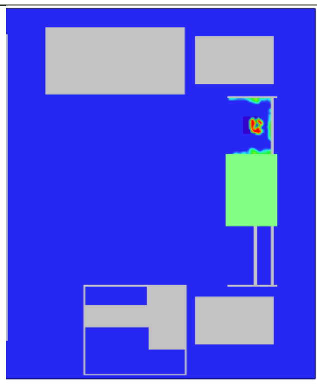
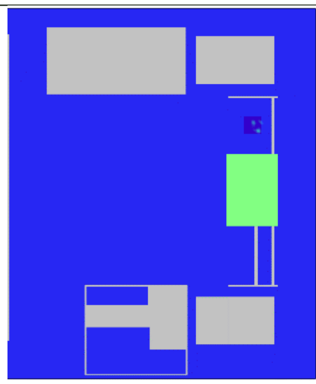
The following views have been used in this report to depict the quantitative results for each simulation listed above.



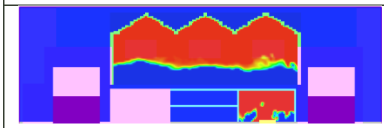
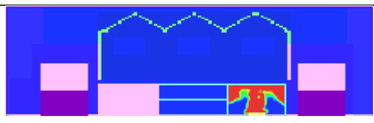
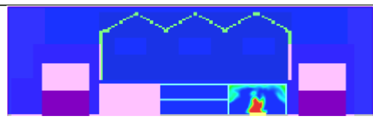
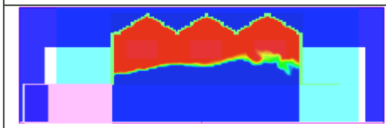
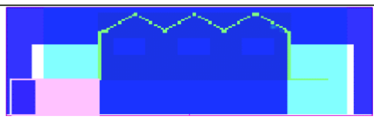
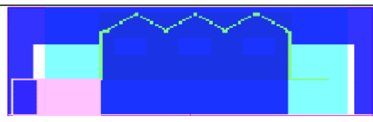
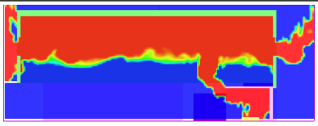
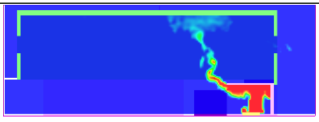
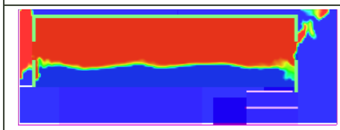
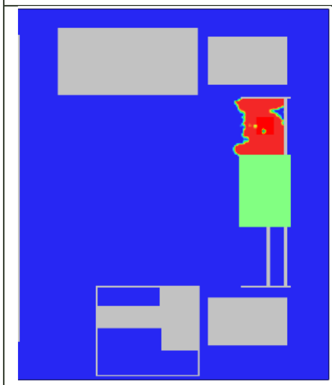
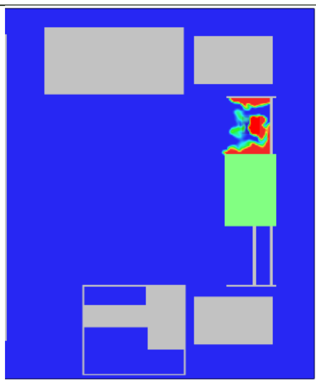
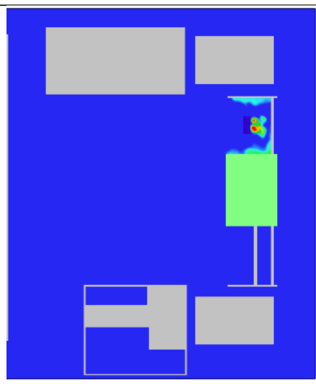
The following graph shows an example of the heat fluxes as measured by devices in the simulations to assess performance relative to the acceptance criteria.



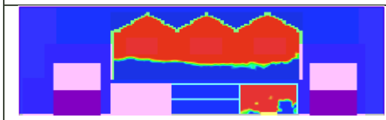
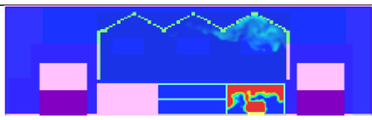
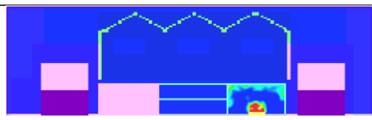
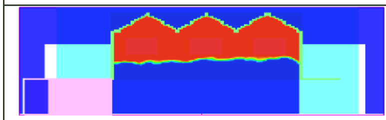
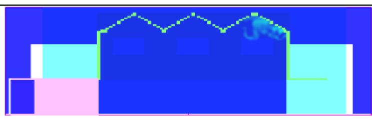
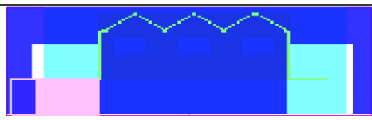
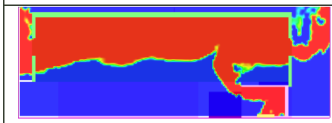
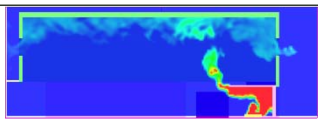
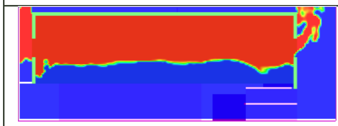
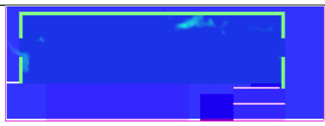
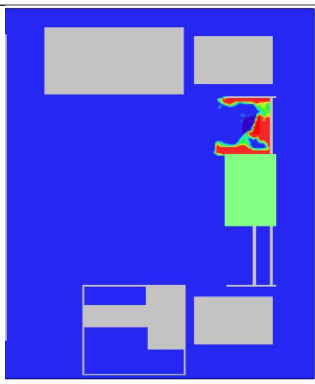
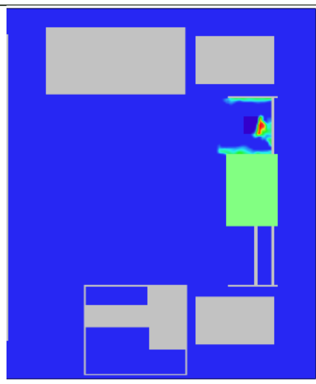
Fire Scenario Temp 1 - Time = 120 seconds

Visibility	Temperature	CO
		
		
		
		
		

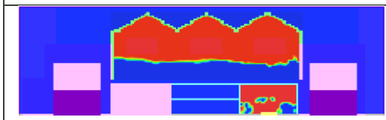
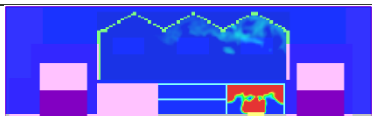
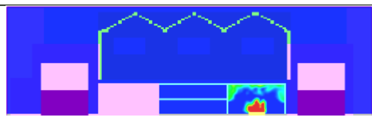
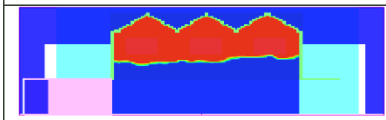
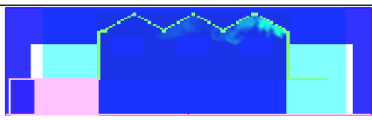
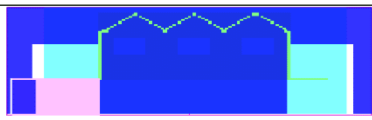
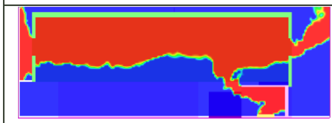
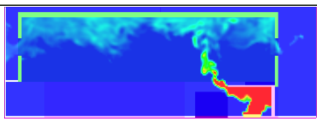
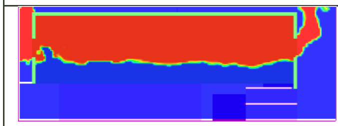
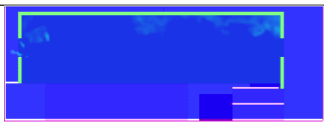
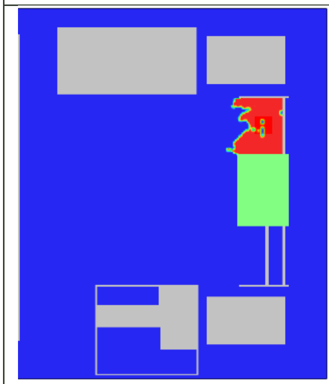
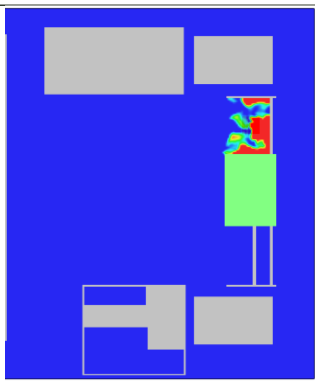
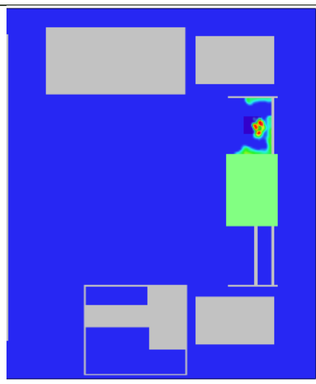
Fire Scenario Temp 1 - Time = 240 seconds

Visibility	Temperature	CO
		
		
		
		
		

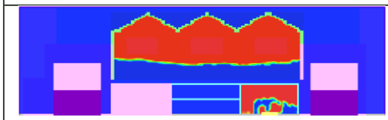
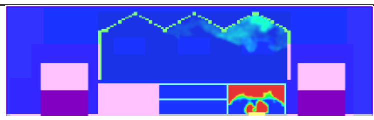
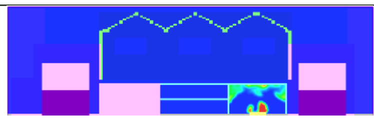
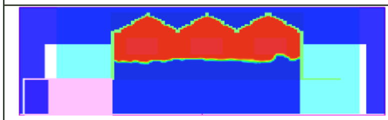
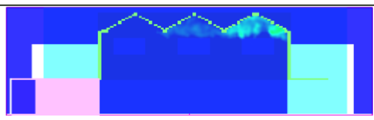
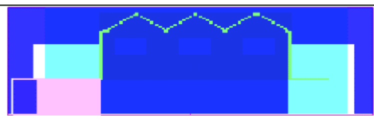
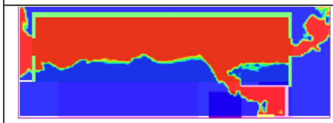
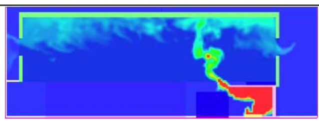
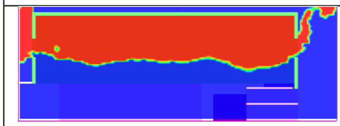
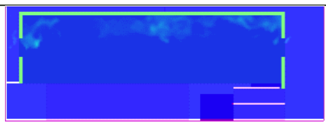
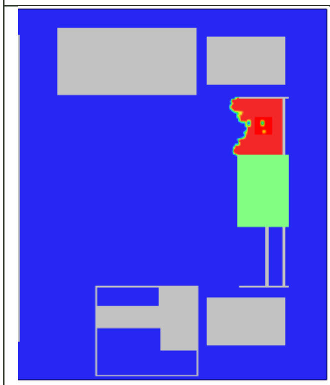
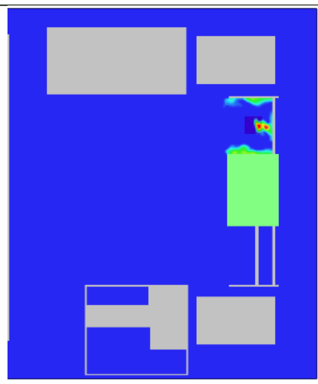
Fire Scenario Temp 1 - Time = 360 seconds

Visibility	Temperature	CO
		
		
		
		
		

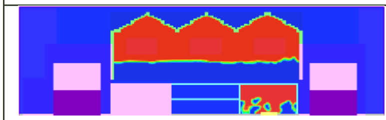
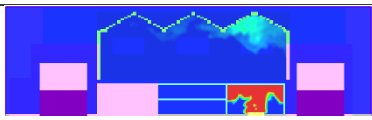
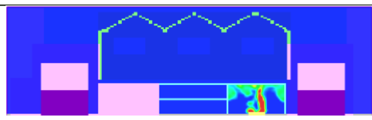
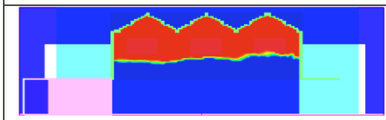
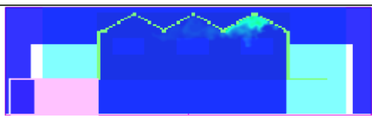
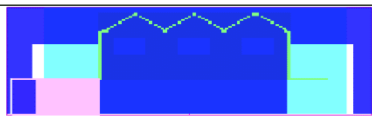
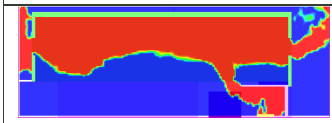
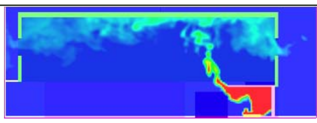
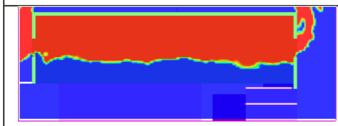
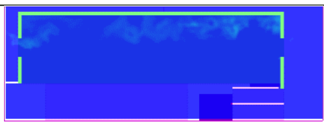
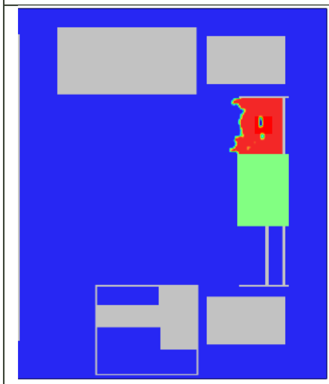
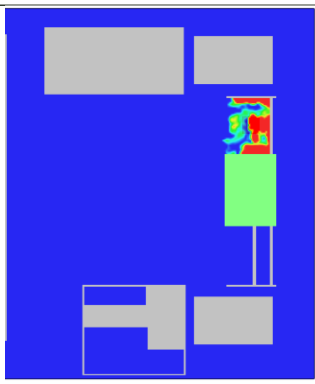
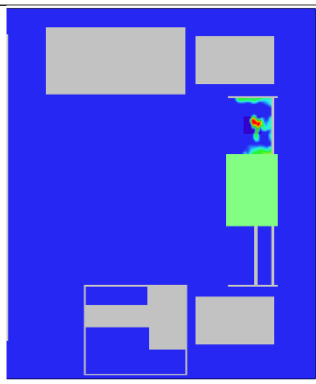
Fire Scenario Temp 1 - Time = 480 seconds

Visibility	Temperature	CO
		
		
		
		
		

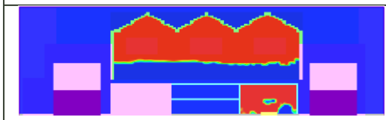
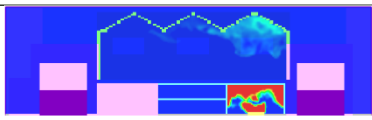
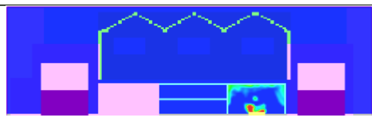
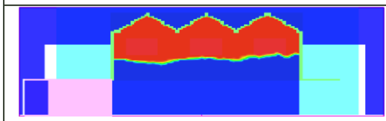
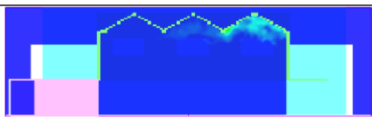
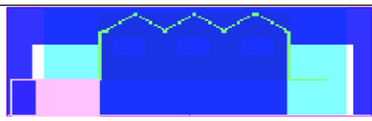
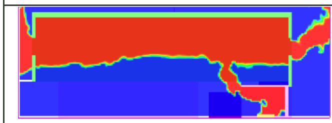
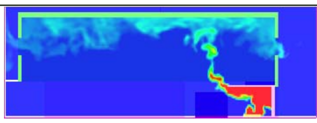
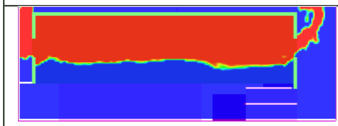
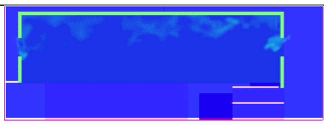
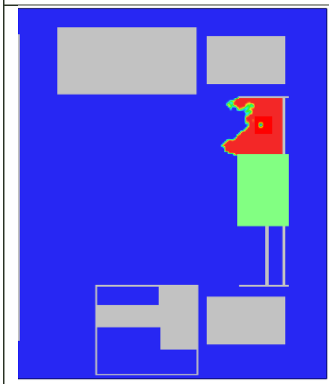
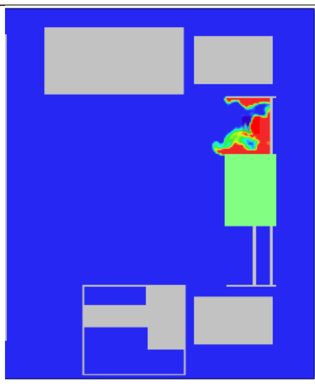
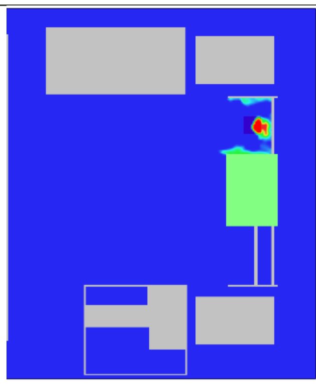
Fire Scenario Temp 1 - Time = 600 seconds

Visibility	Temperature	CO
		
		
		
		
		

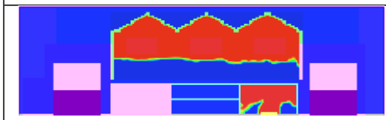
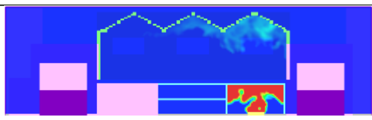
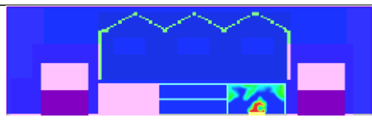
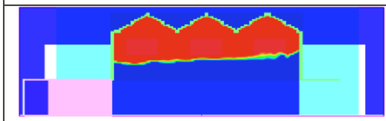
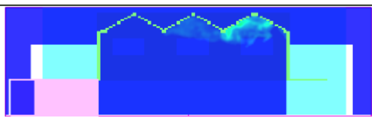
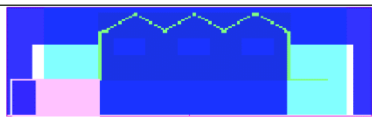
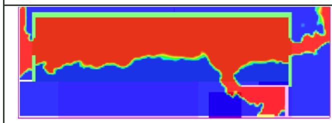
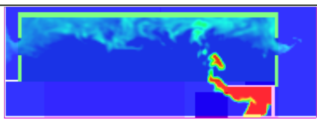
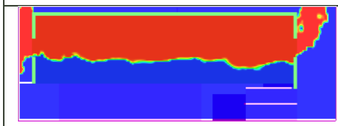
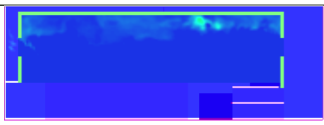
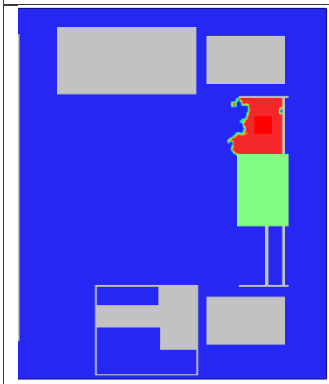
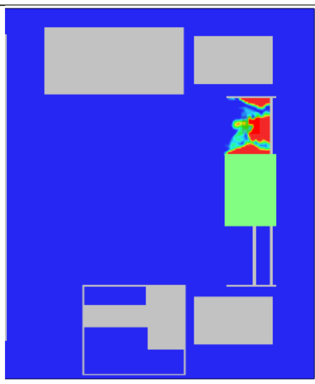
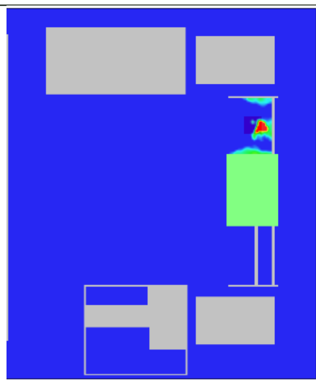
Fire Scenario Temp 1 - Time = 720 seconds

Visibility	Temperature	CO
		
		
		
		
		

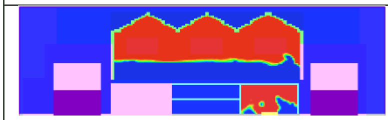
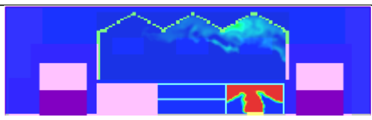
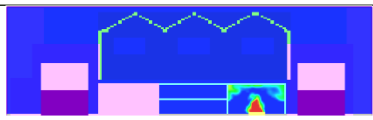
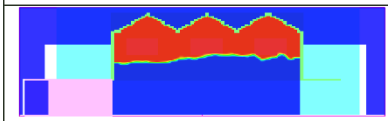
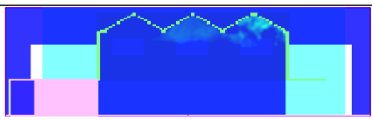
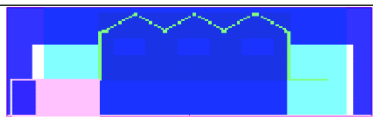
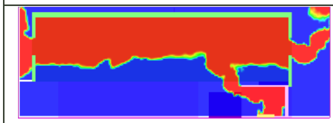
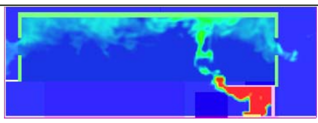
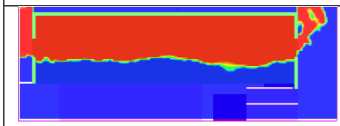
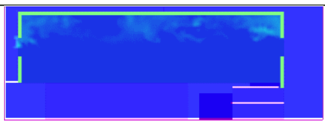
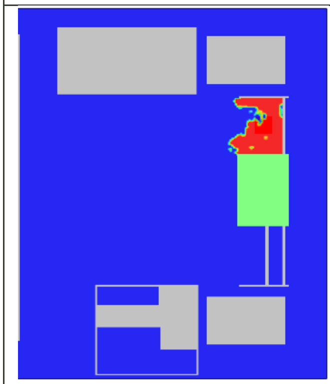
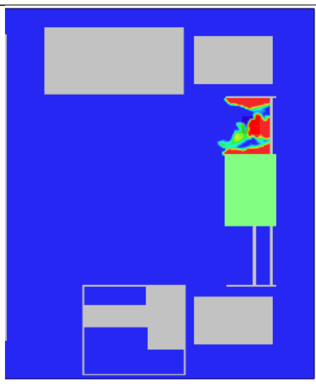
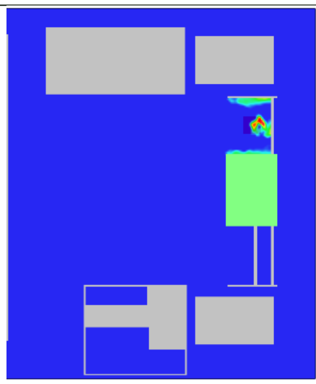
Fire Scenario Temp 1 - Time = 840 seconds

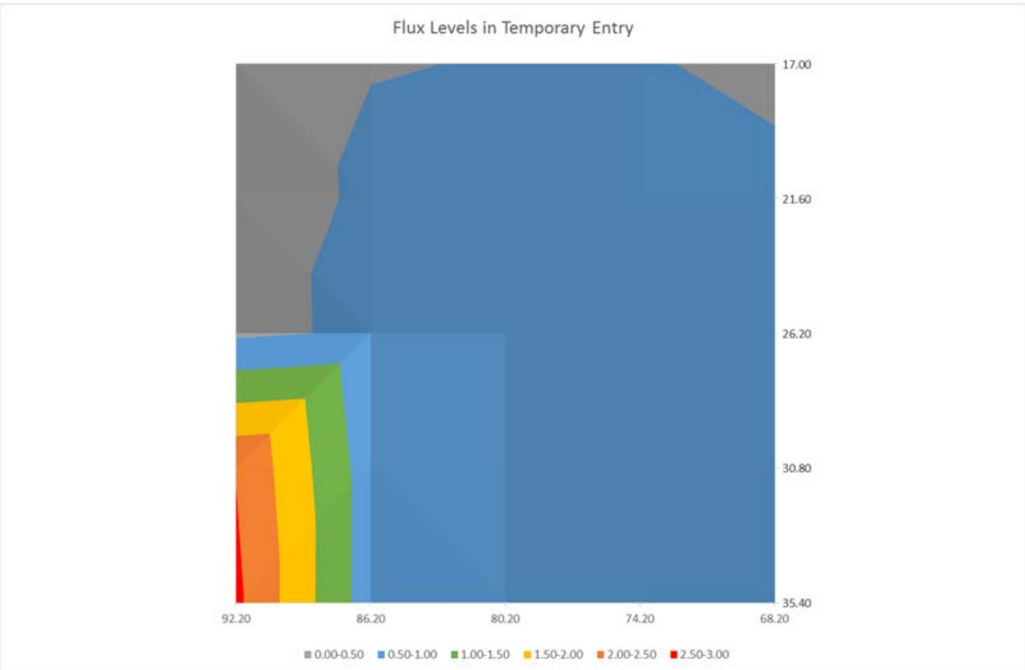
Visibility	Temperature	CO
		
		
		
		
		

Fire Scenario Temp 1 - Time = 960 seconds

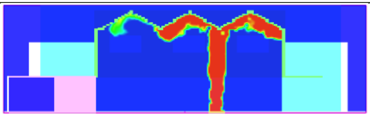
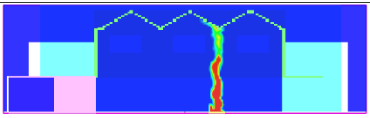
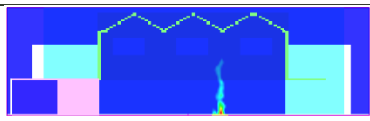
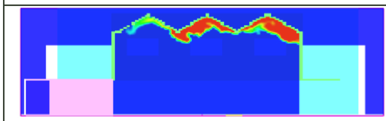
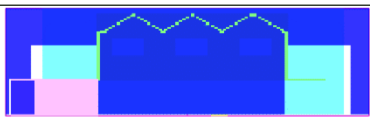
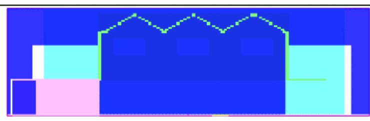
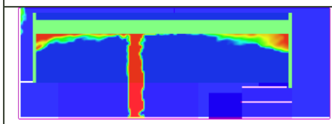
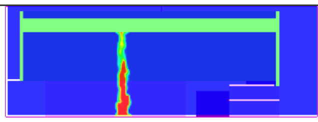
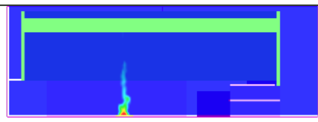
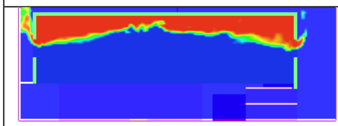
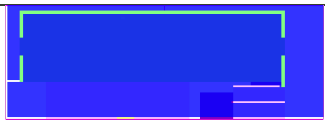
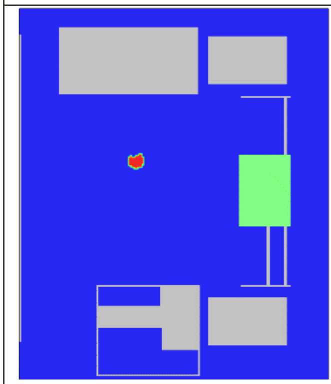
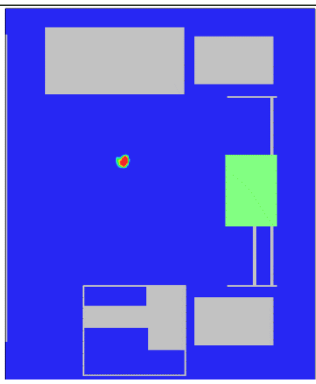
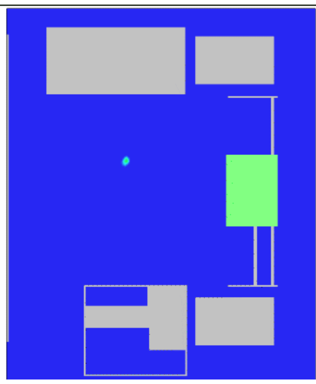
Visibility	Temperature	CO
		
		
		
		
		

Fire Scenario Temp 1 - Time = 1,200 seconds

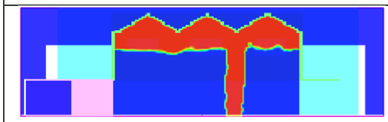
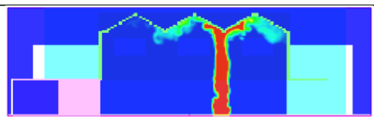
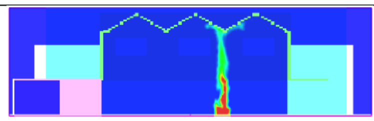
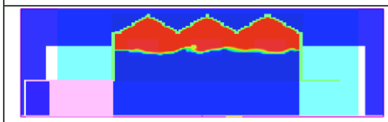
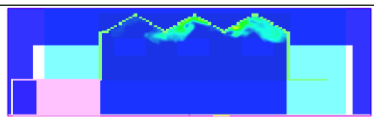
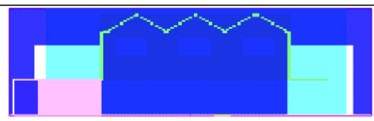
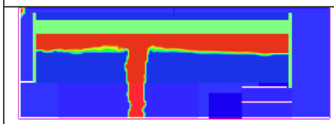
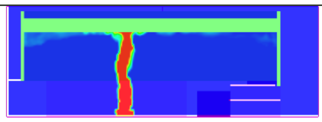
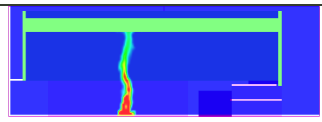
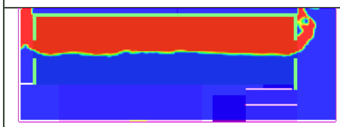
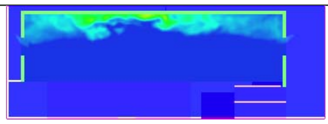
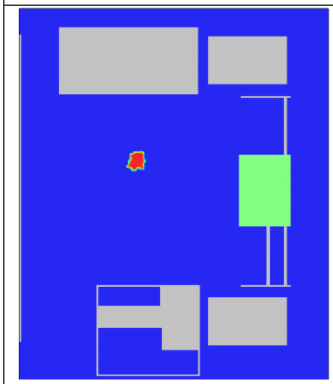
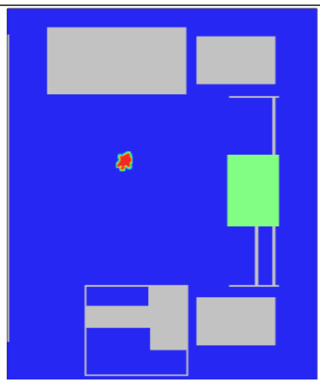
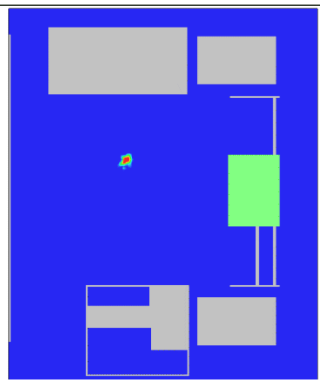
Visibility	Temperature	CO
		
		
		
		
		



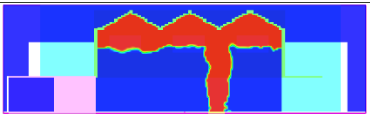
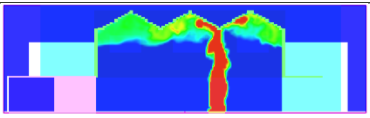
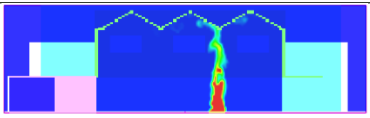
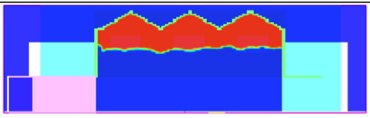
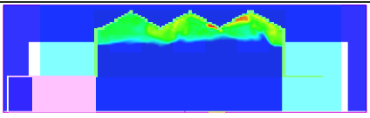
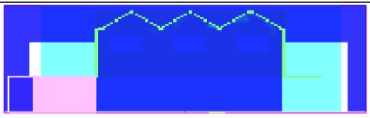
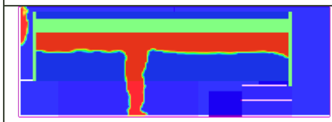
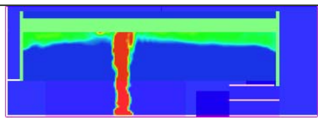
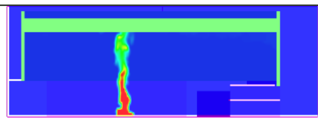
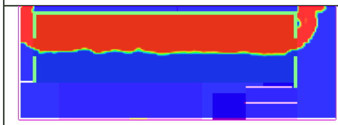
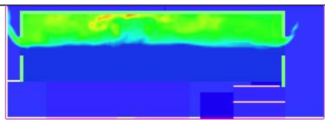
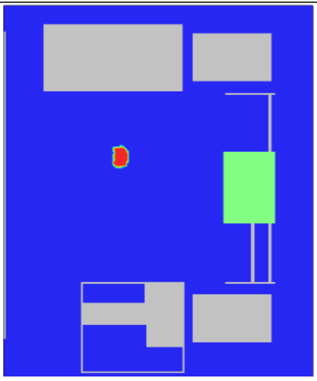
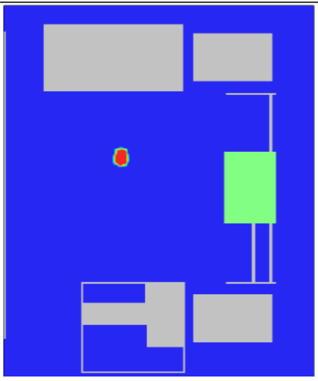
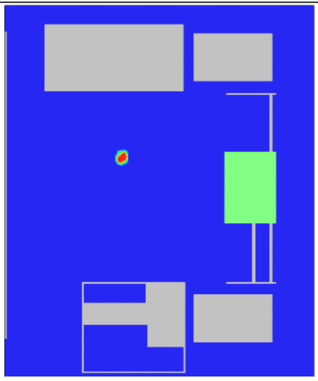
Fire Scenario Temp 2 - Time = 120 seconds

Visibility	Temperature	CO
		
		
		
		
		

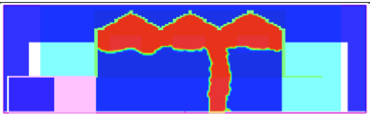
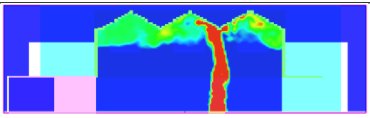
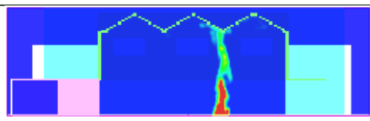
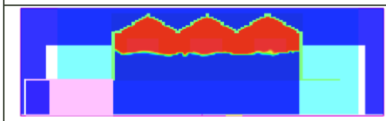
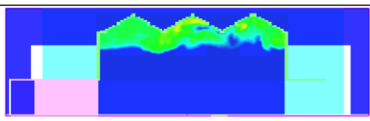
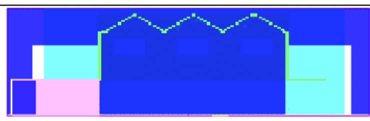
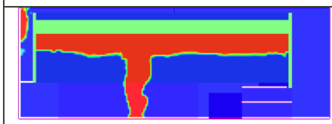
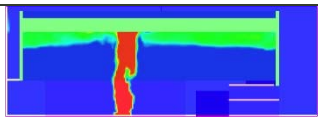
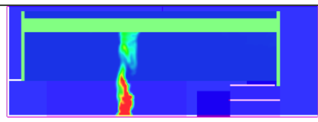
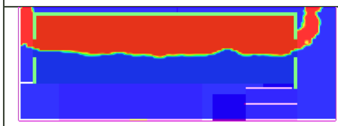
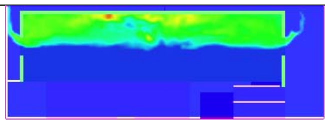
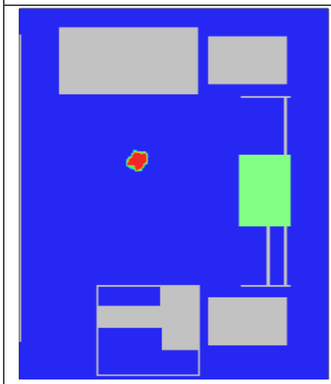
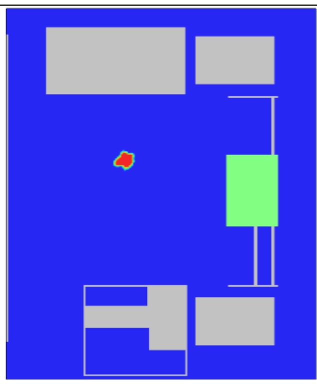
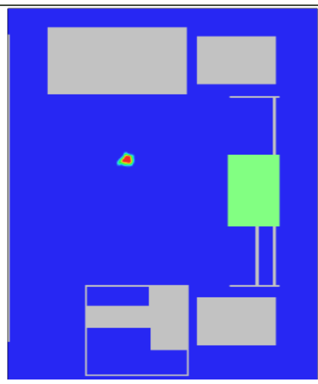
Fire Scenario Temp 2 - Time = 240 seconds

Visibility	Temperature	CO
		
		
		
		
		

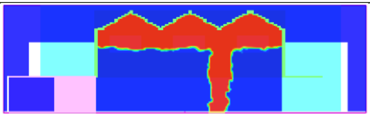
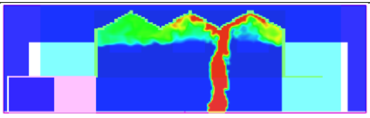
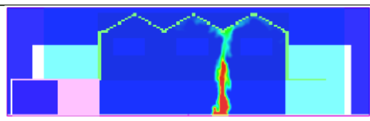
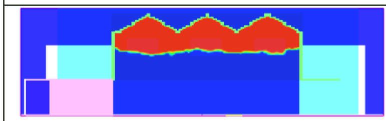
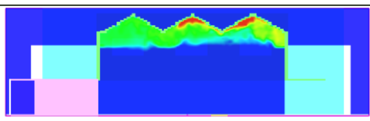
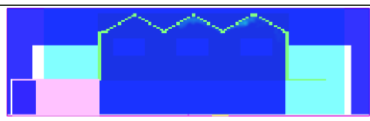
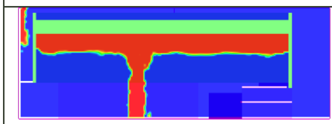
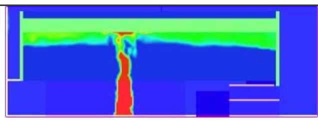
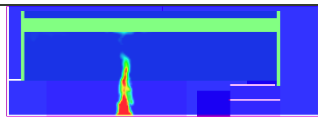
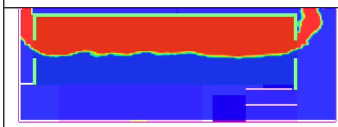
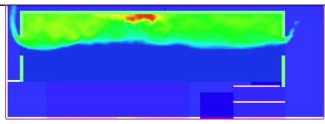
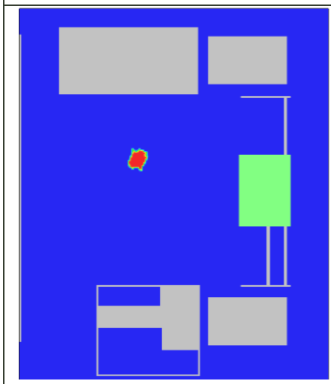
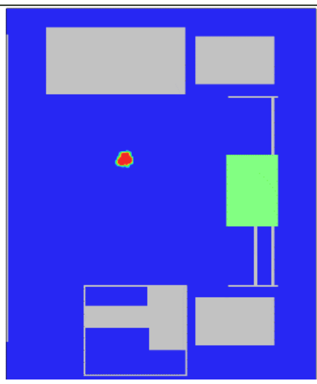
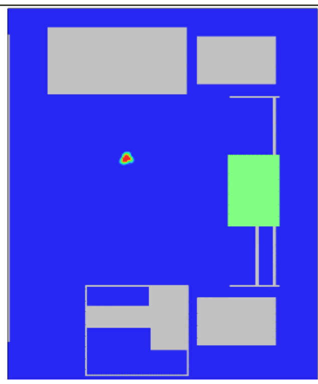
Fire Scenario Temp 2 - Time = 360 seconds

Visibility	Temperature	CO
		
		
		
		
		

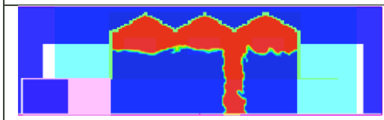
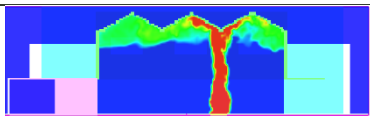
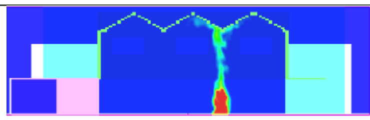
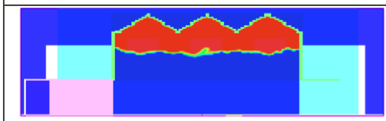
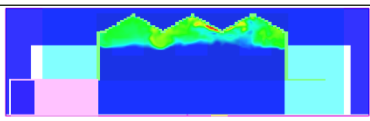
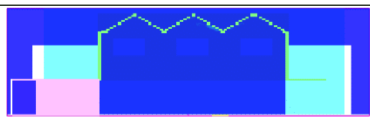
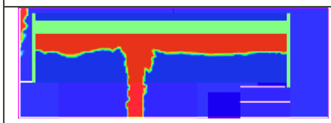
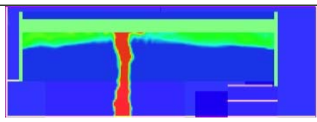
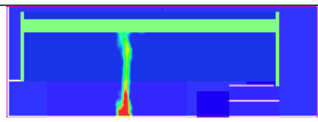
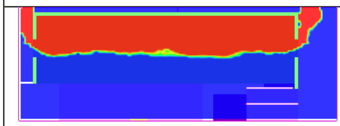
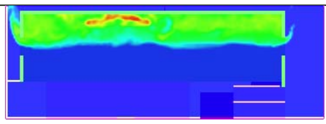
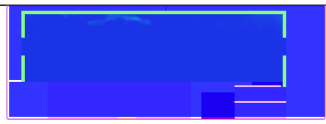
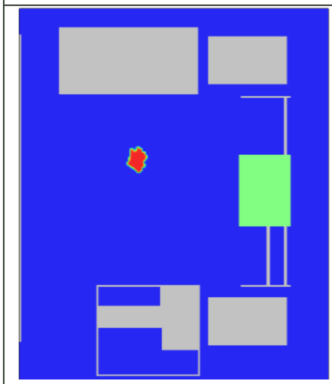
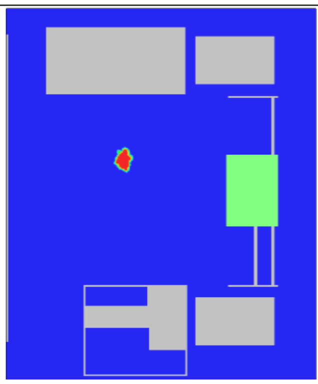
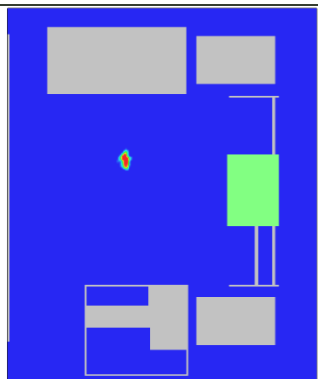
Fire Scenario Temp 2 - Time = 480 seconds

Visibility	Temperature	CO
		
		
		
		
		

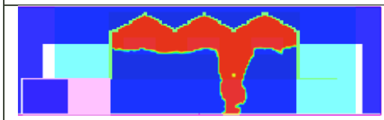
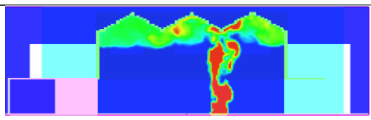
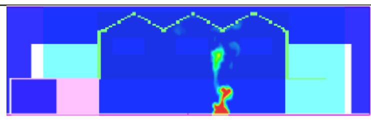
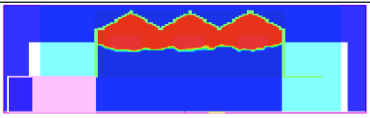
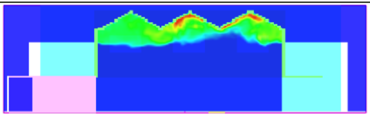
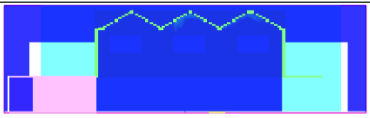
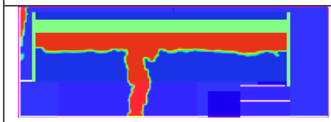
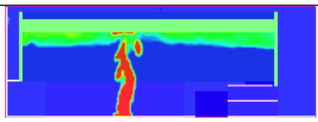
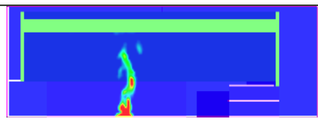
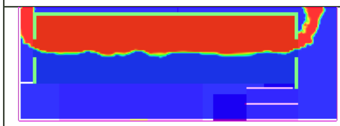
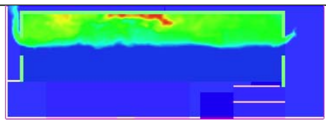
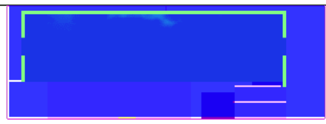
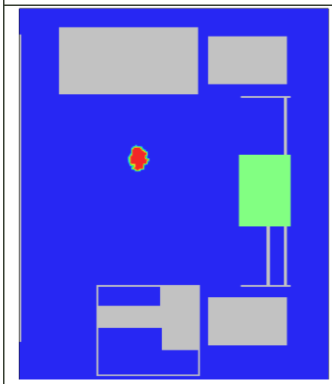
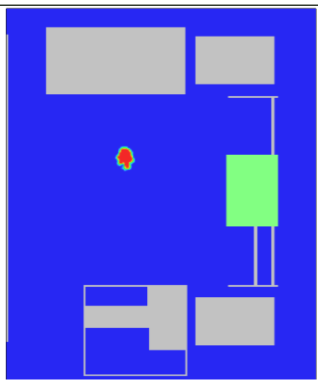
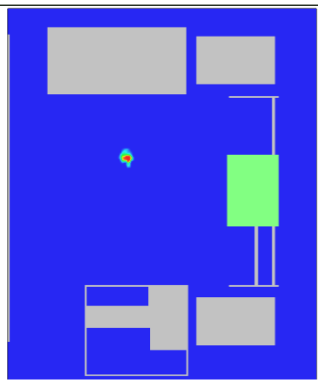
Fire Scenario Temp 2 - Time = 600 seconds

Visibility	Temperature	CO
		
		
		
		
		

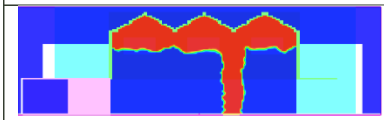
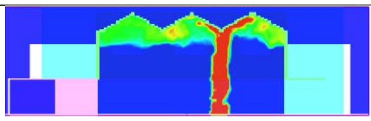
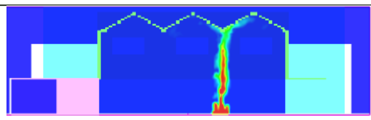
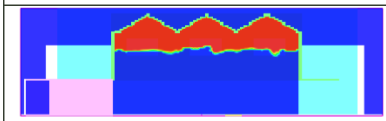
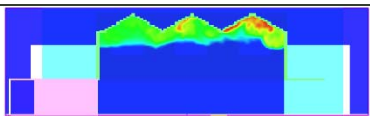
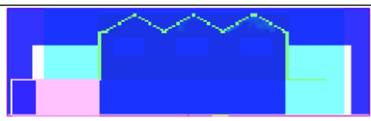
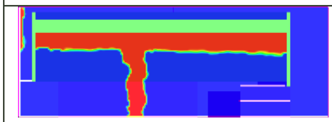
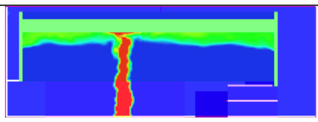
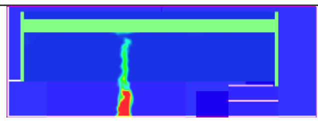
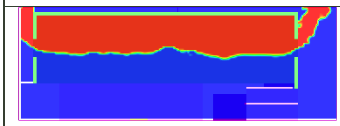
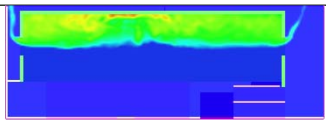
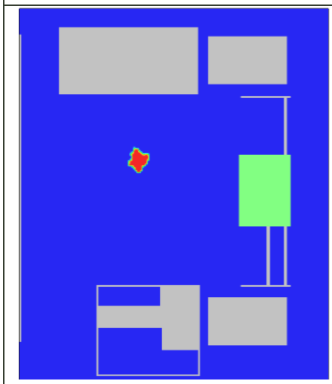
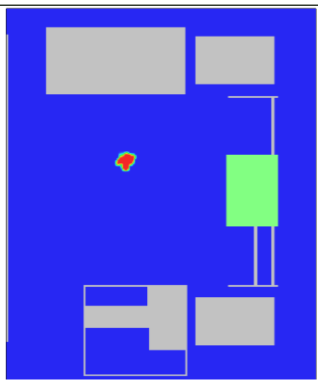
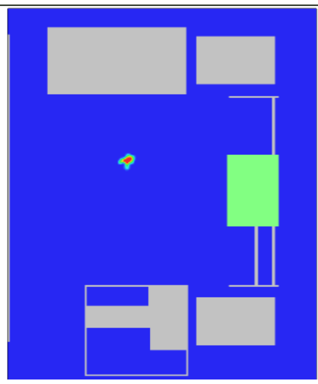
Fire Scenario Temp 2 - Time = 720 seconds

Visibility	Temperature	CO
		
		
		
		
		

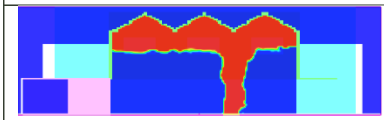
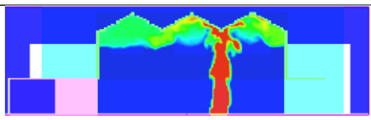
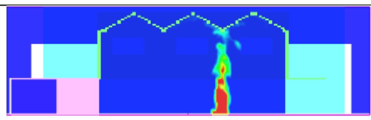
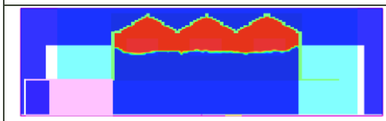
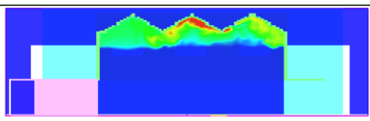
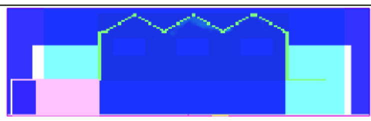
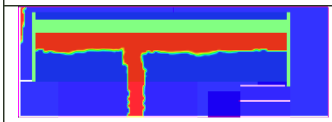
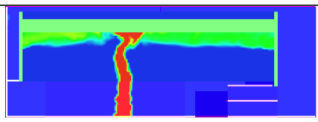
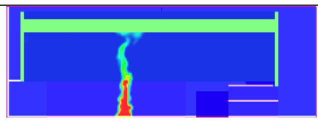
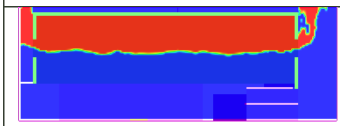
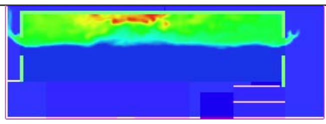
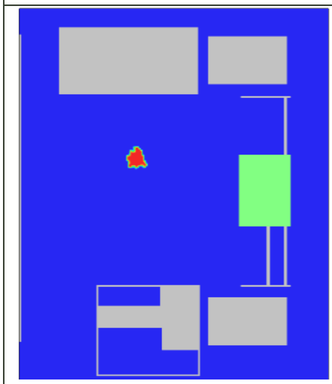
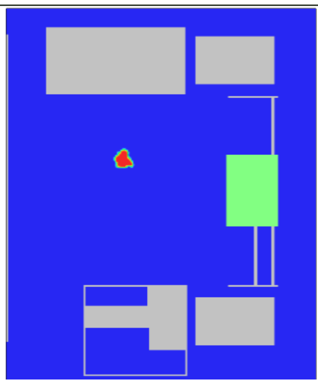
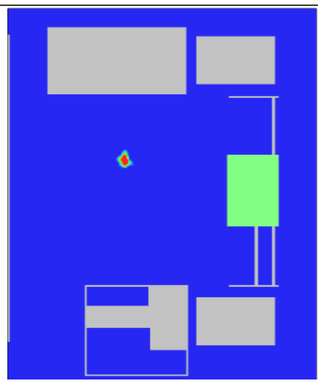
Fire Scenario Temp 2 - Time = 840 seconds

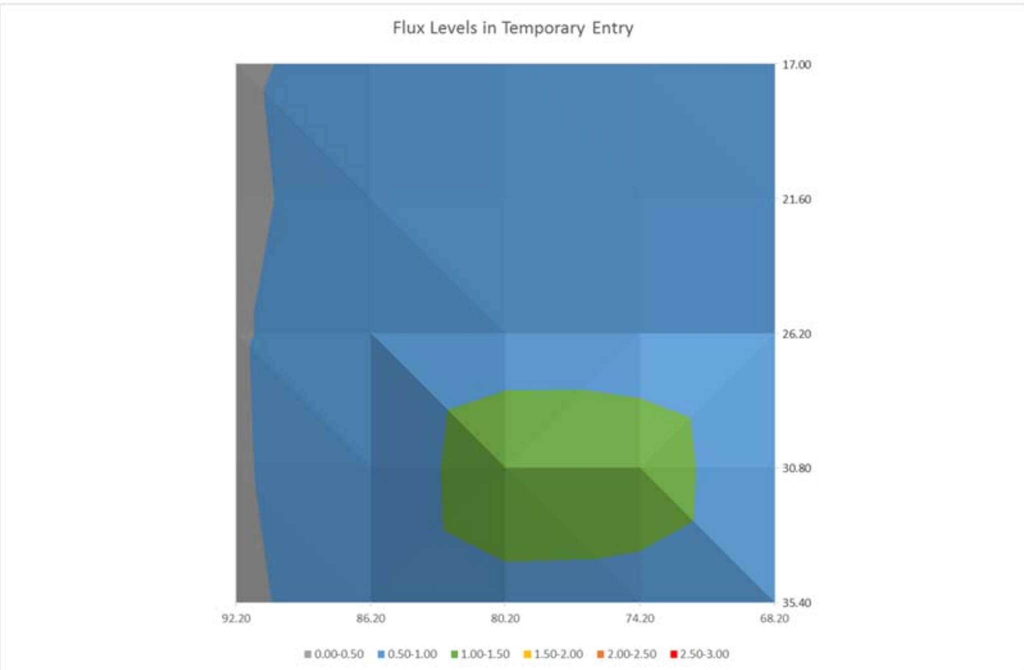
Visibility	Temperature	CO
		
		
		
		
		

Fire Scenario Temp 2 - Time = 960 seconds

Visibility	Temperature	CO
		
		
		
		
		

Fire Scenario Temp 2 - Time = 1,200 seconds

Visibility	Temperature	CO
		
		
		
		
		



Appendix H
Temporary Works FDS Results

Temporary Works Fire Models

Fire Scenario	Run ID	Location	Design Fires	Active Fire Systems	Case
1E	01	Track 1 Carriage 1 (highest challenge location)	Fast t² 4 MW	Fully functioning	Base Case
2E	02	Track 3, Carriage 1	Fast t² 4 MW	Fully functioning	Base Case
3E	03	Track 1, Carriage 6 (highest challenge east end)	Fast t² 4 MW	Fully functioning	Base Case
4E	04	Track 3, Carriage 6	Fast t² 4 MW	Fully functioning	Base Case
5E	05	Track 1 Carriage 1	Medium t² 10 MW	Fully functioning	Sensitivity
6E		Track 1 Carriage 1	Fast t² 4 MW	50% mechanical exhaust	Redundancy
7E	10	Track 1 Carriage 1	Fast t² 4 MW	Smoke curtain failure	Redundancy

Legend

<u>Data bounds</u>

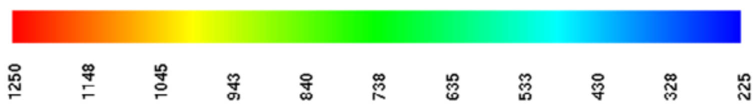
Visibility

m

Temperature

°C

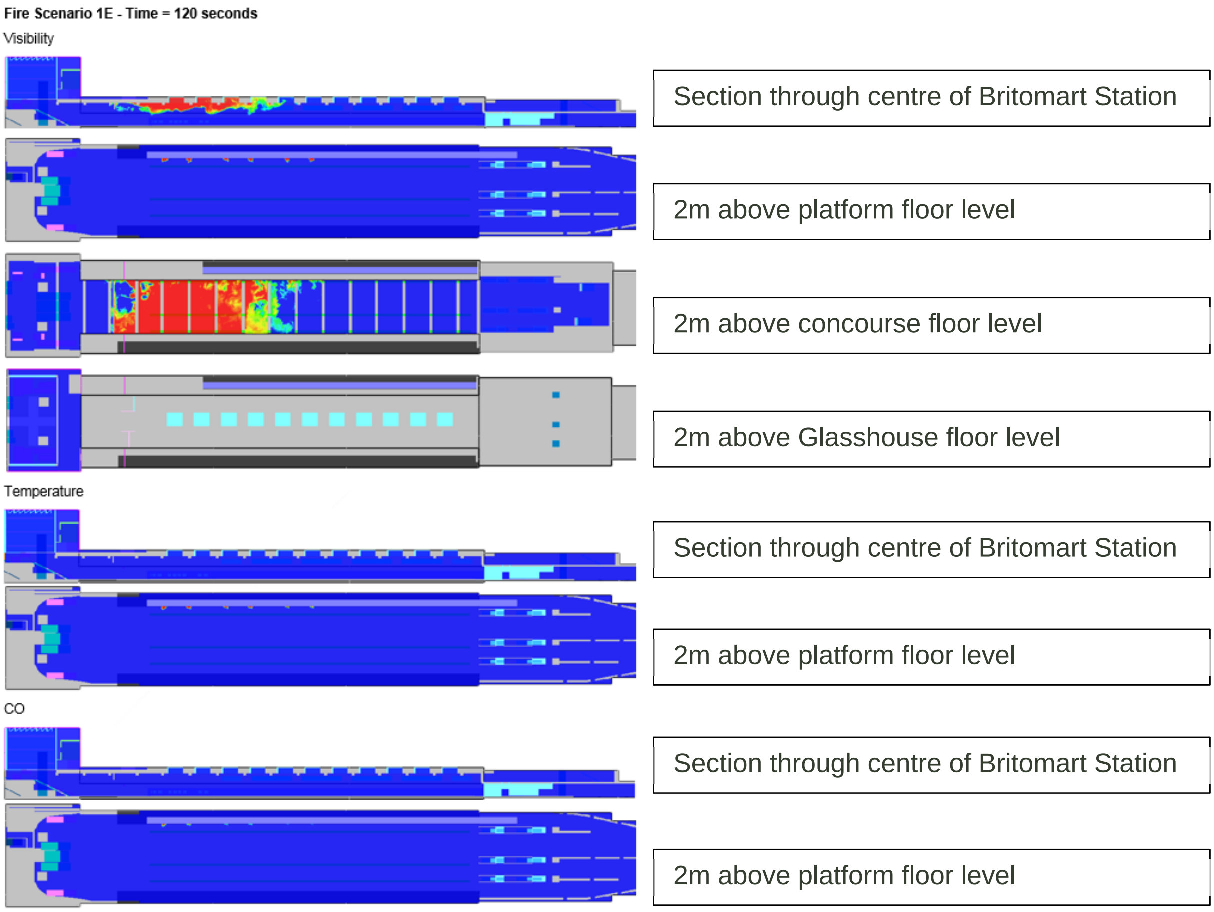
CO Concentration



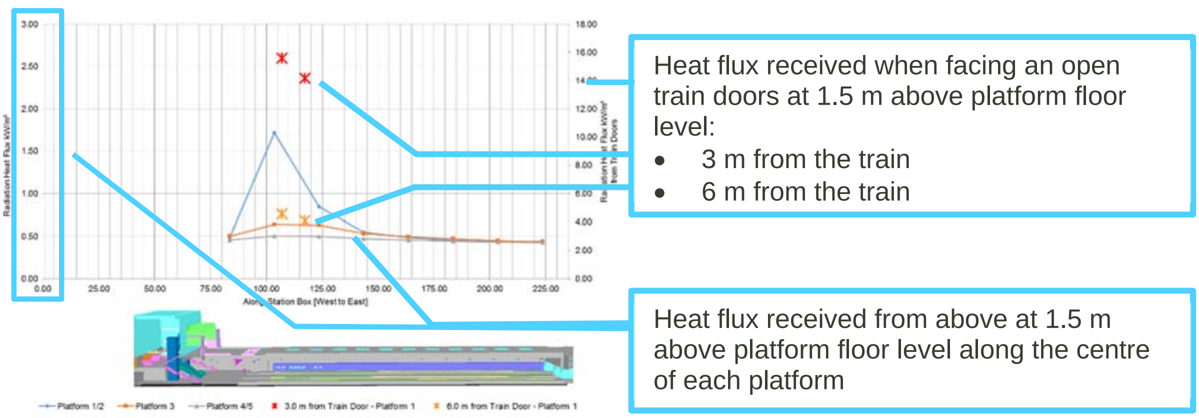
ppm

Views

The following views have been used in this report to depict the quantitative results for each simulation listed above.

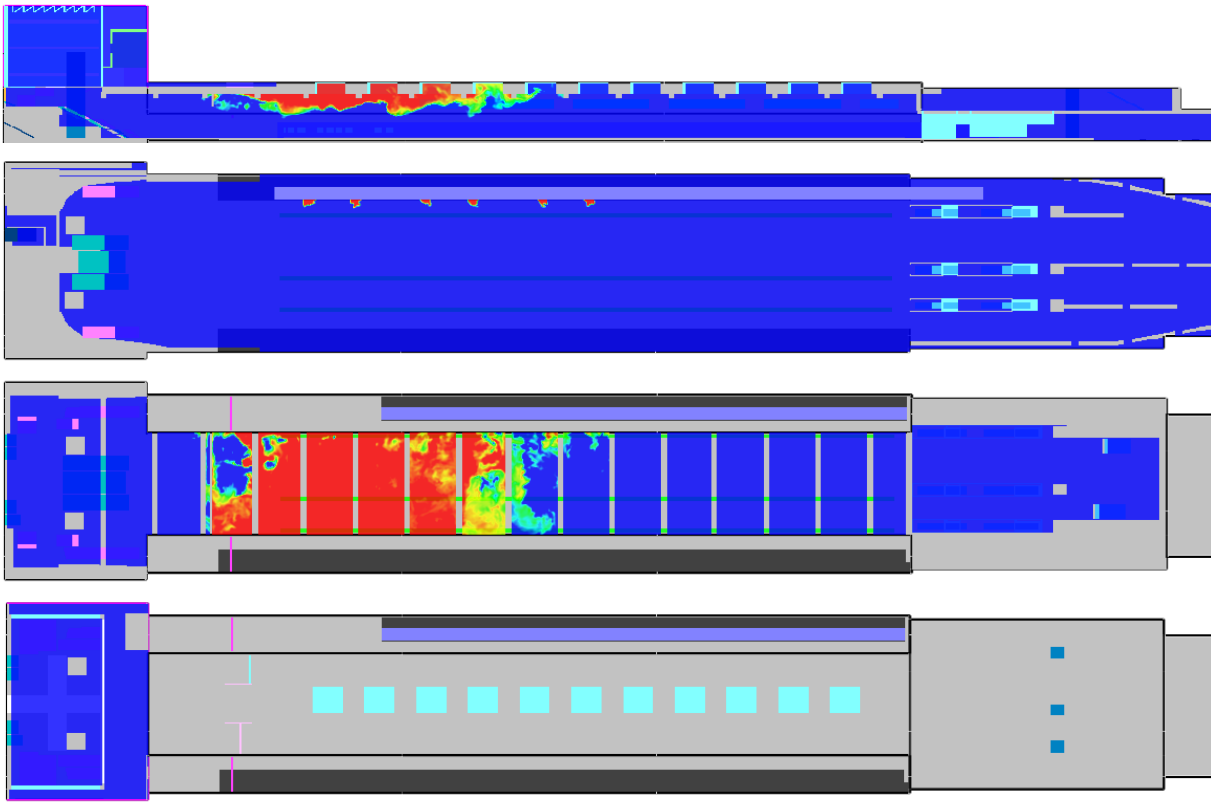


The following graph shows an example of the heat fluxes as measured by devices in the simulations to assess performance relative to the acceptance criteria.

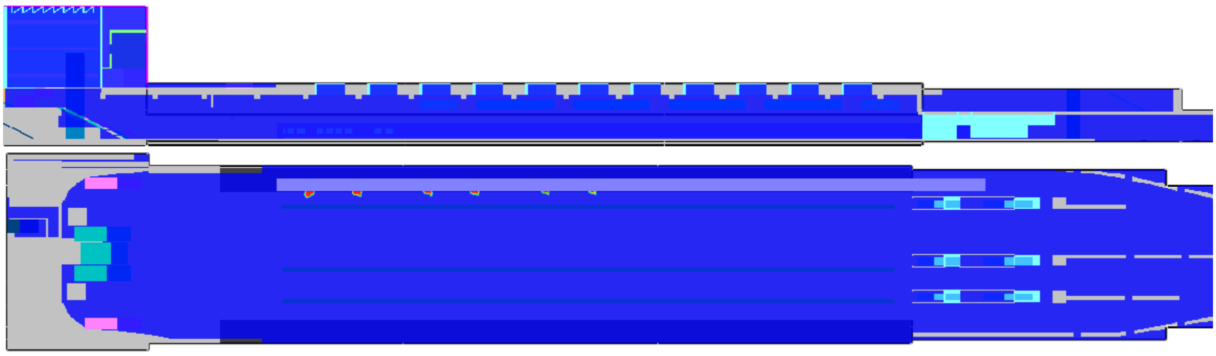


Fire Scenario 1E - Time = 120 seconds

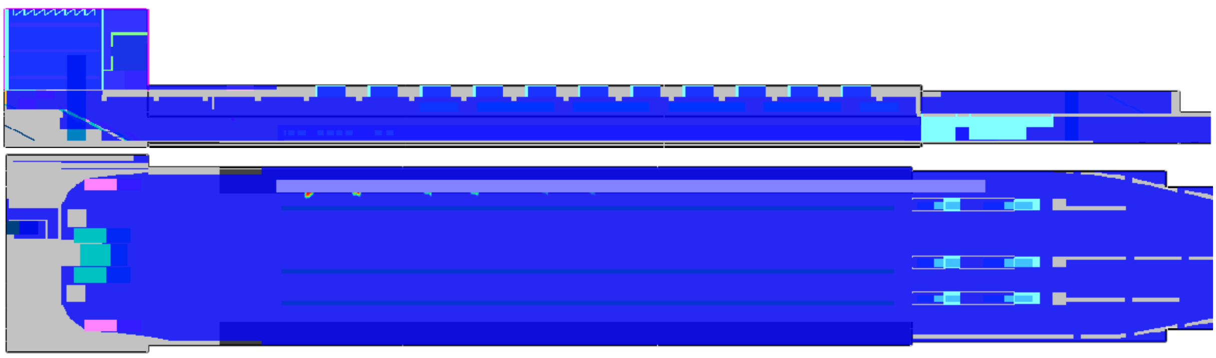
Visibility



Temperature

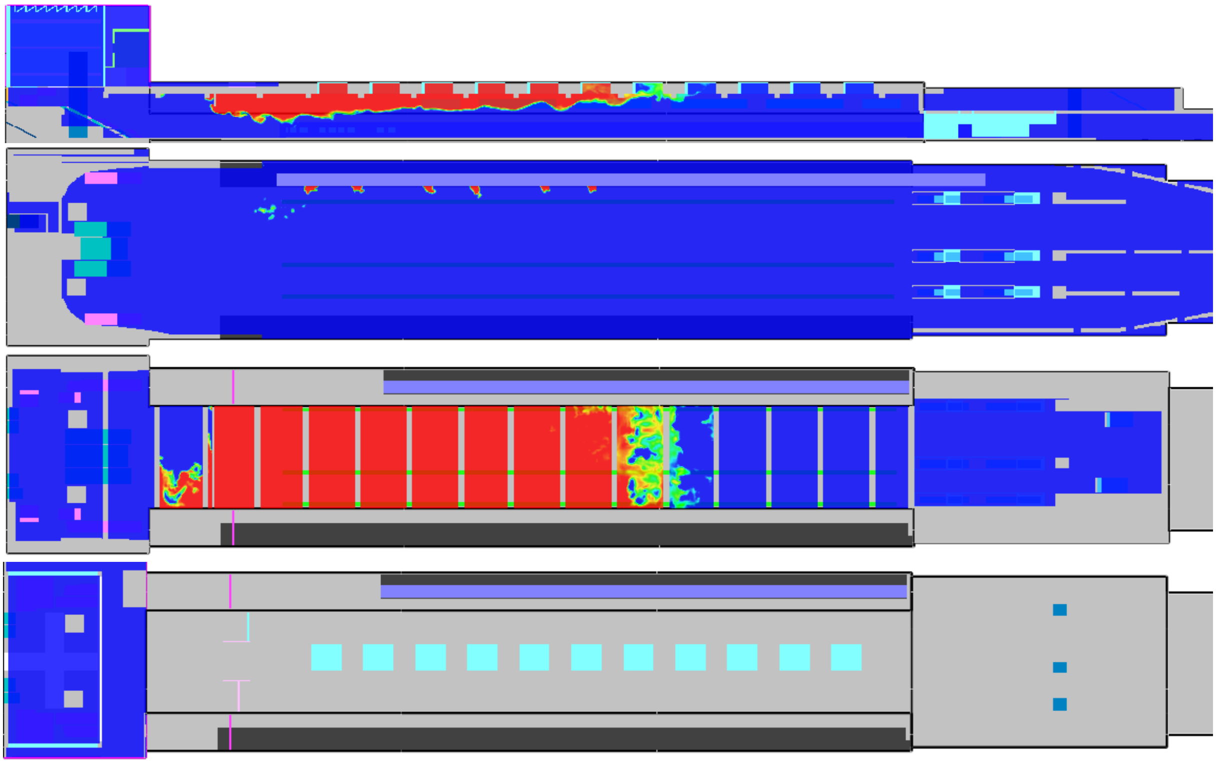


CO

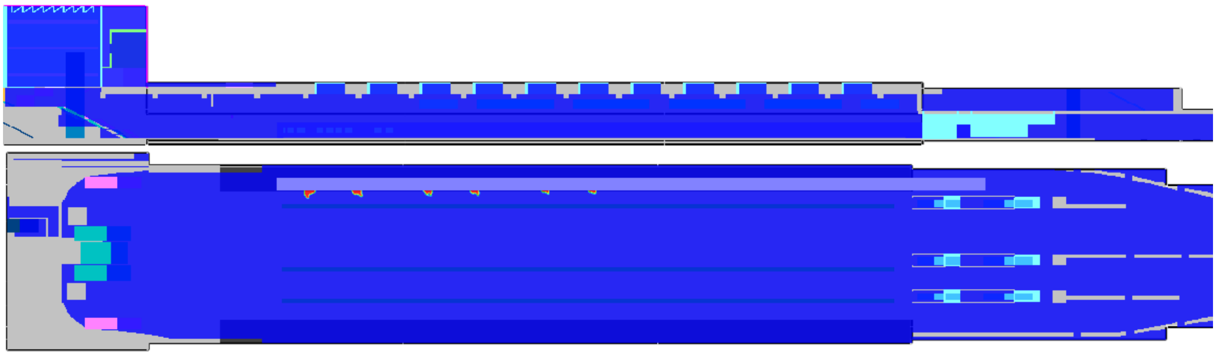


Fire Scenario 1E - Time = 240 seconds

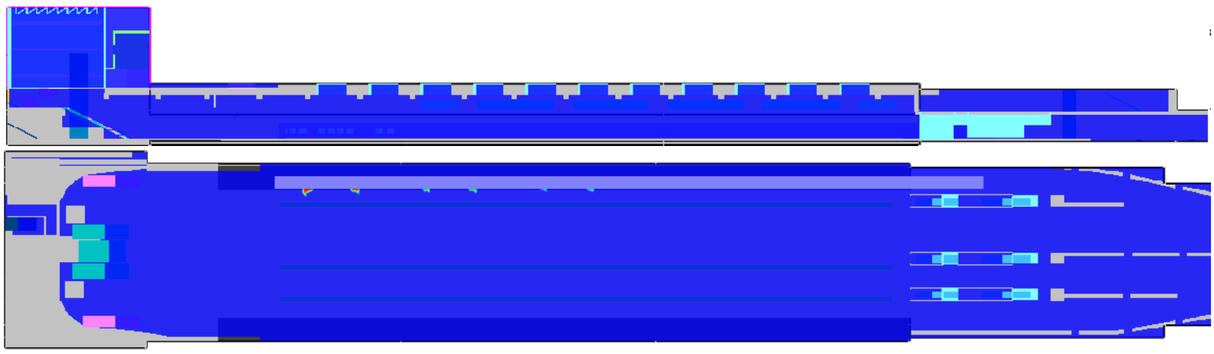
Visibility



Temperature

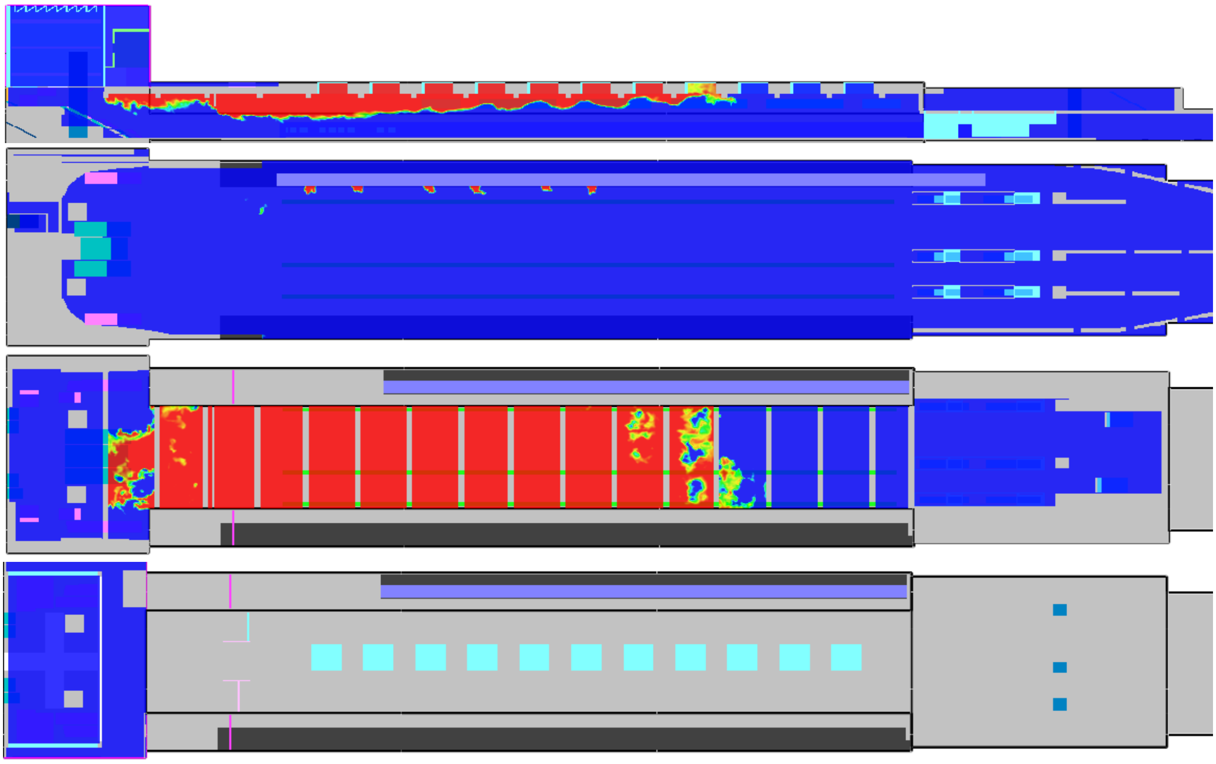


CO

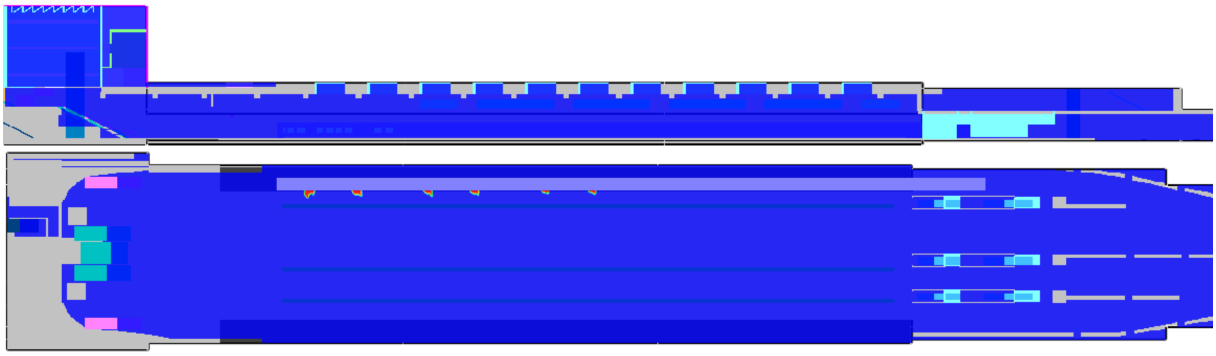


Fire Scenario 1E - Time = 360 seconds

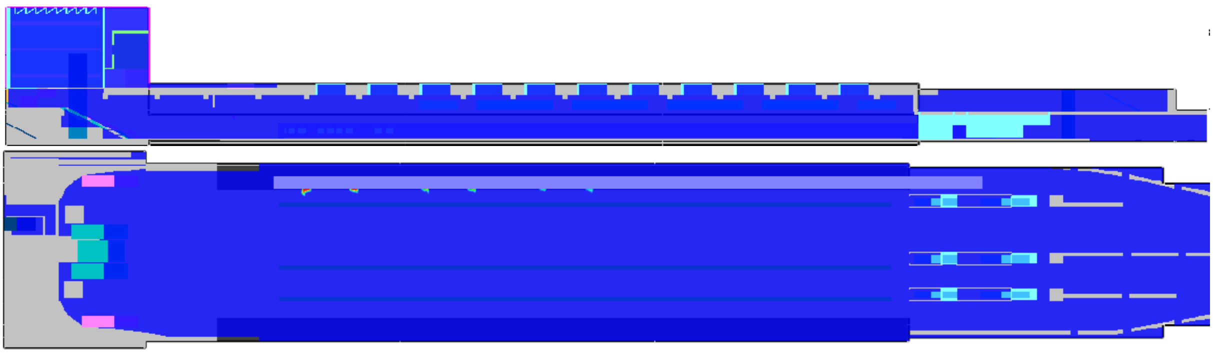
Visibility



Temperature

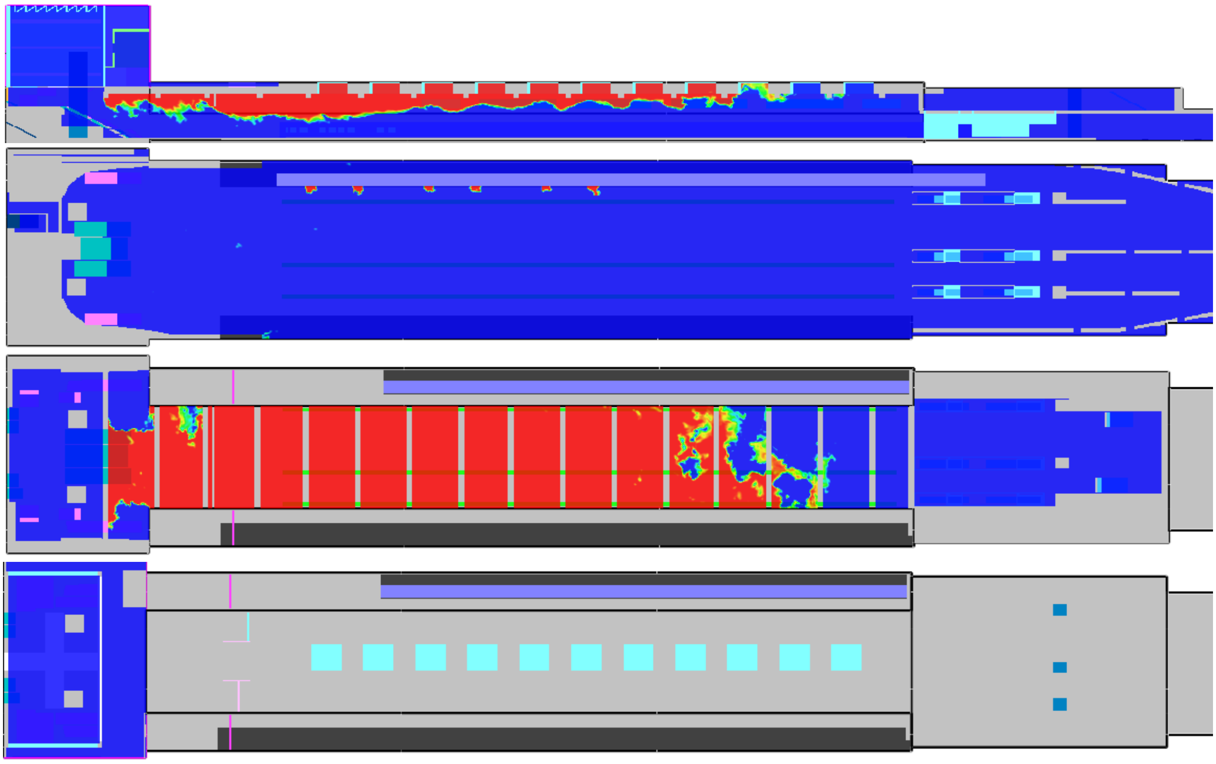


CO

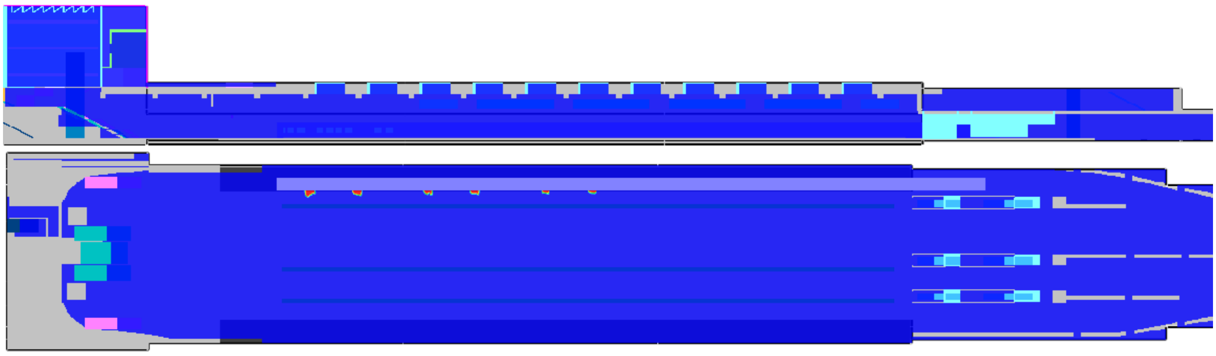


Fire Scenario 1E - Time = 480 seconds

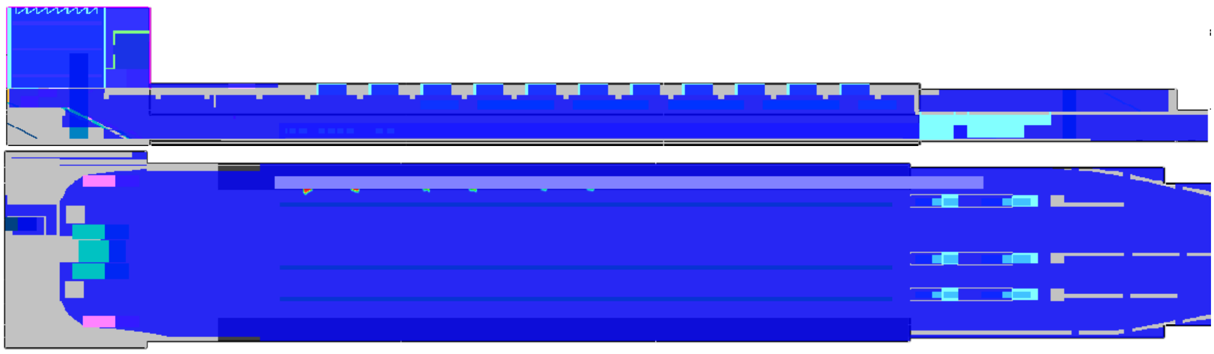
Visibility



Temperature

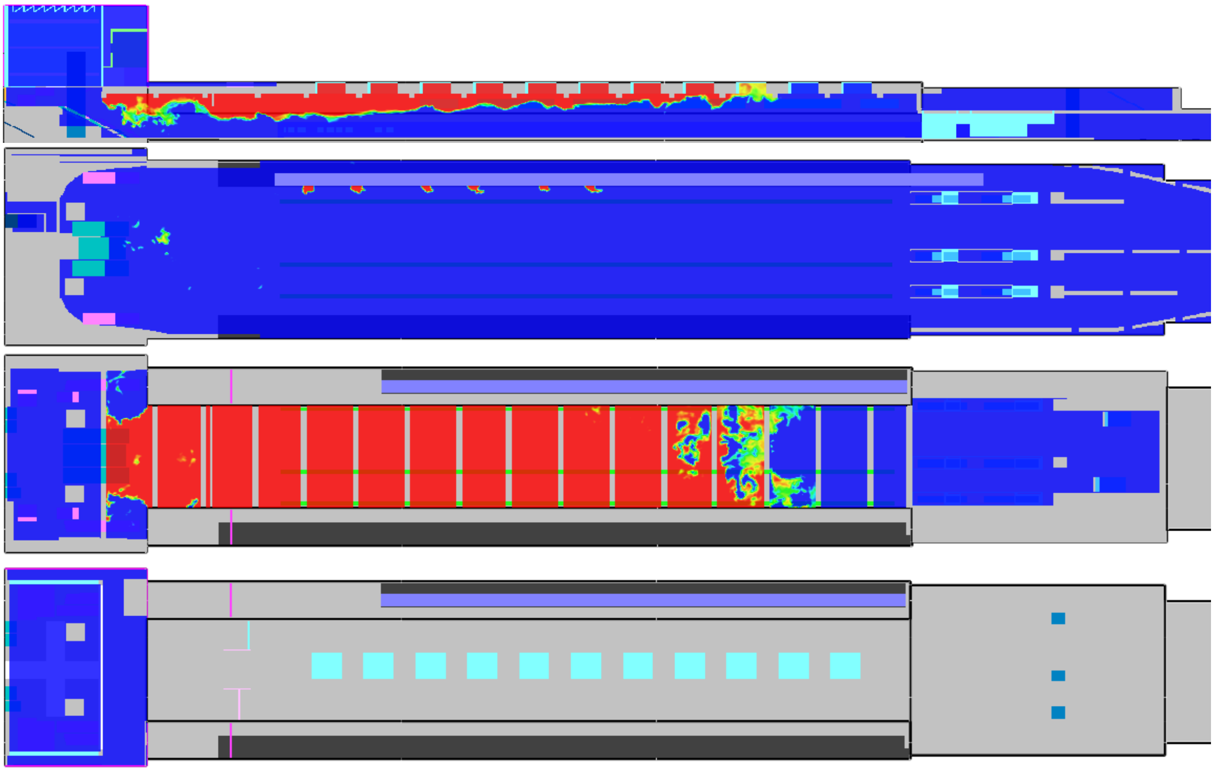


CO

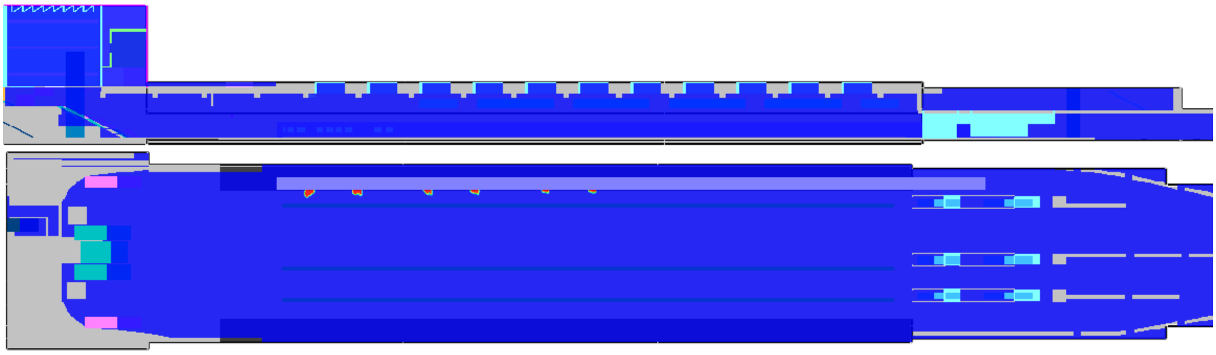


Fire Scenario 1E - Time = 600 seconds

Visibility



Temperature



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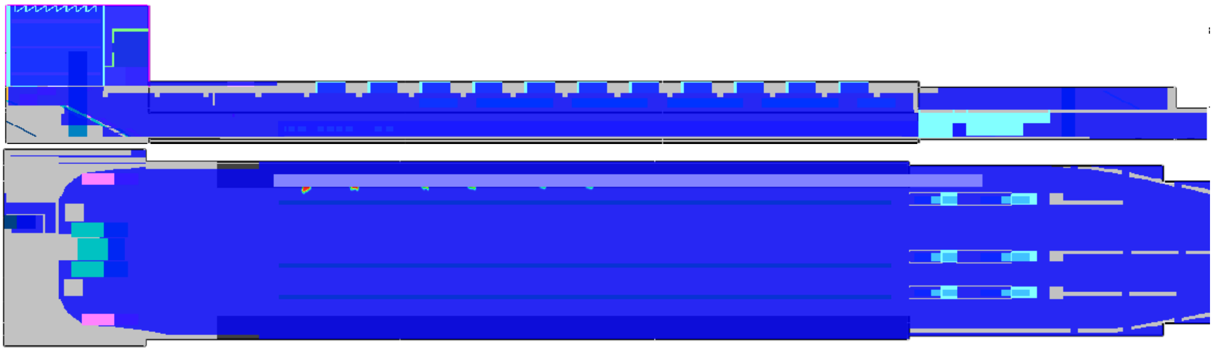
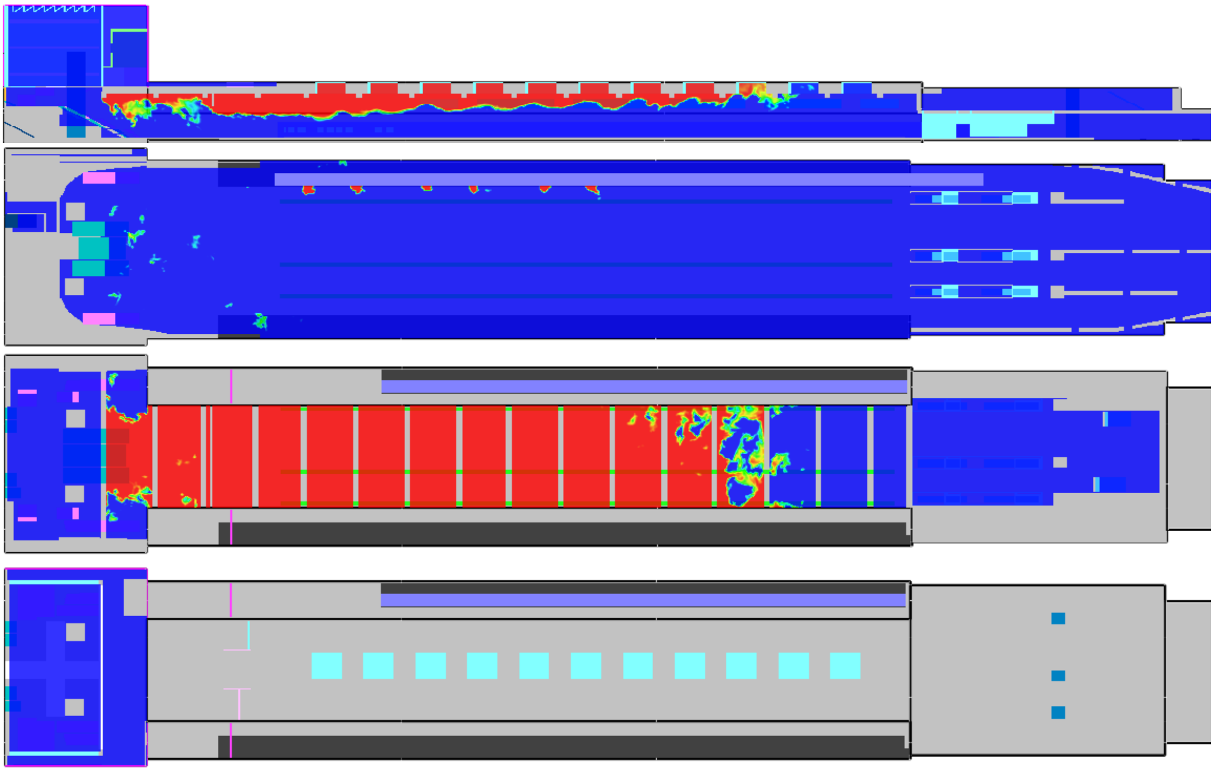
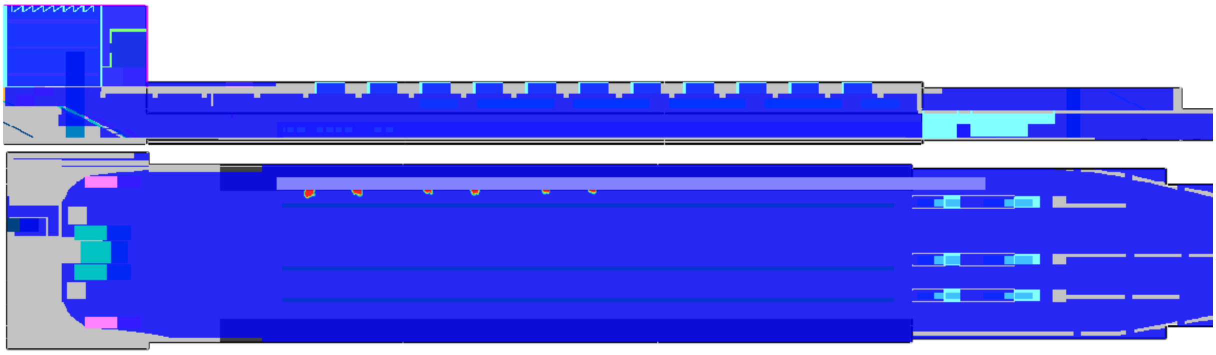


Fire Scenario 1E - Time = 720 seconds

Visibility



Temperature



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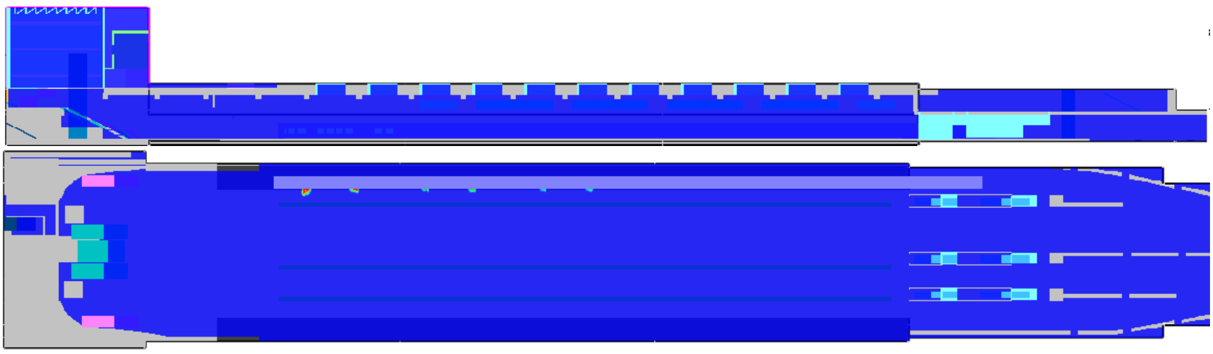
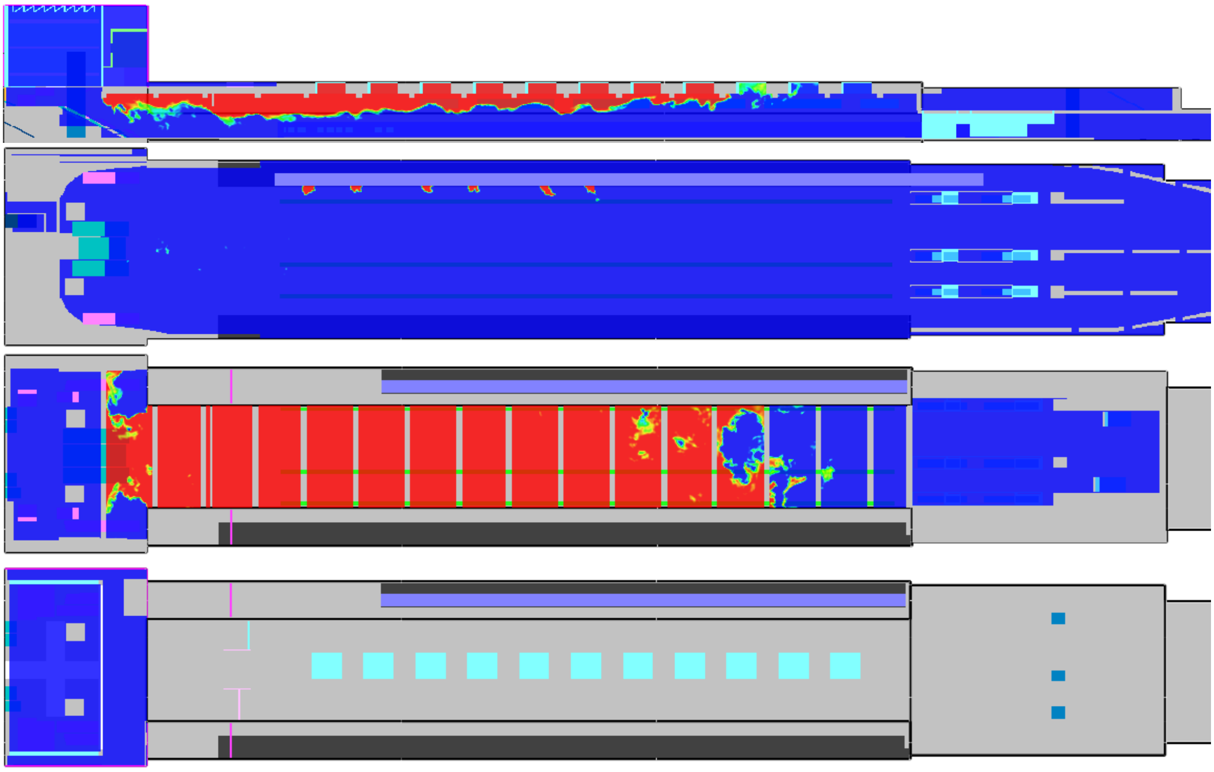
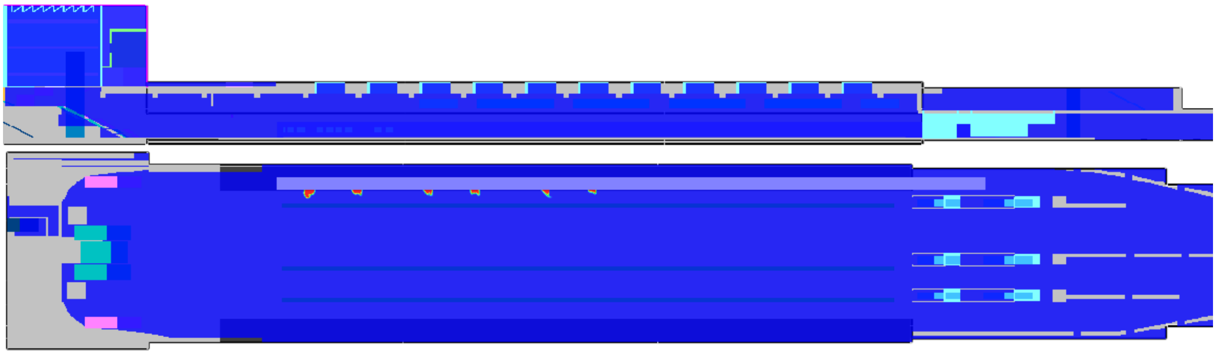


Fire Scenario 1E - Time = 840 seconds

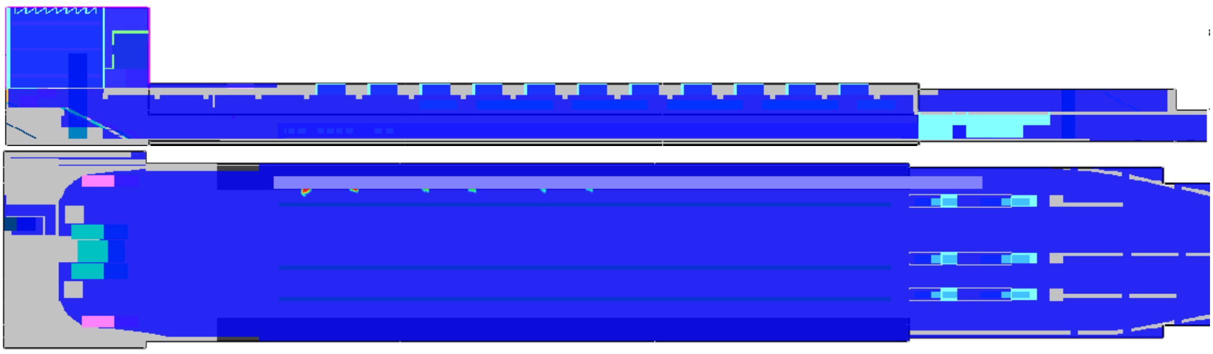
Visibility



Temperature

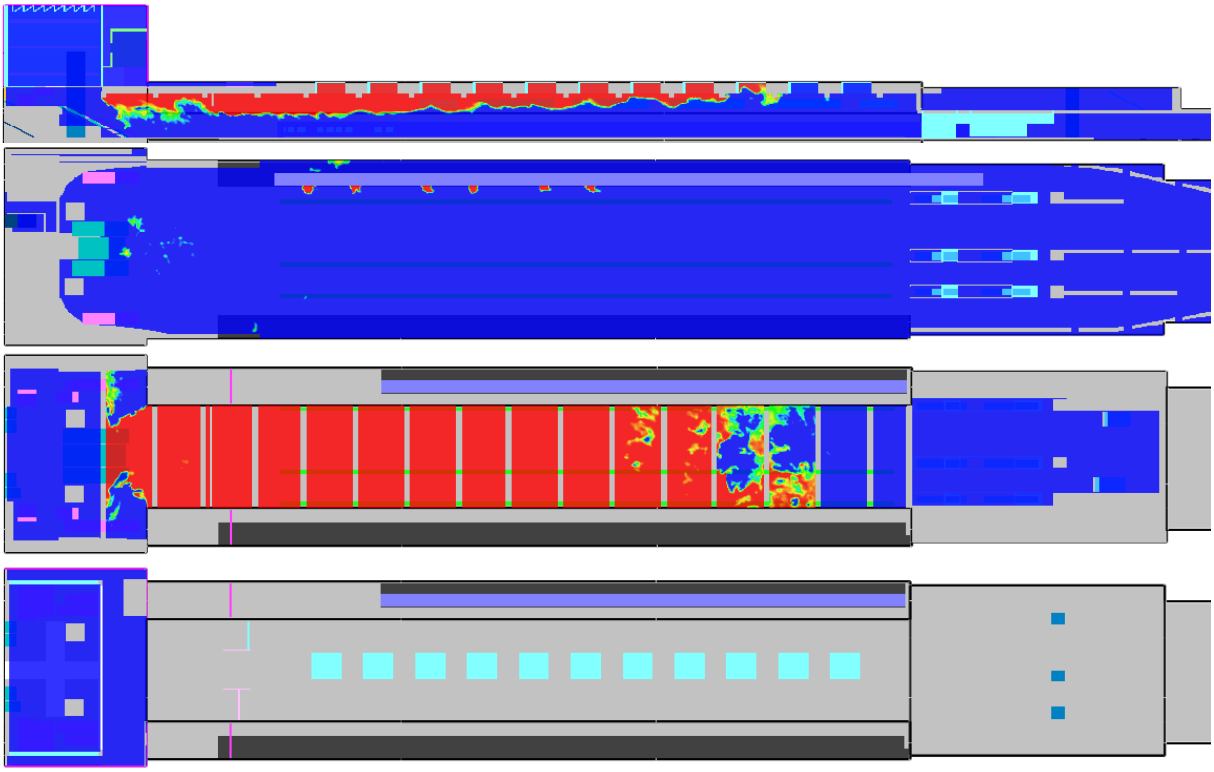


CO

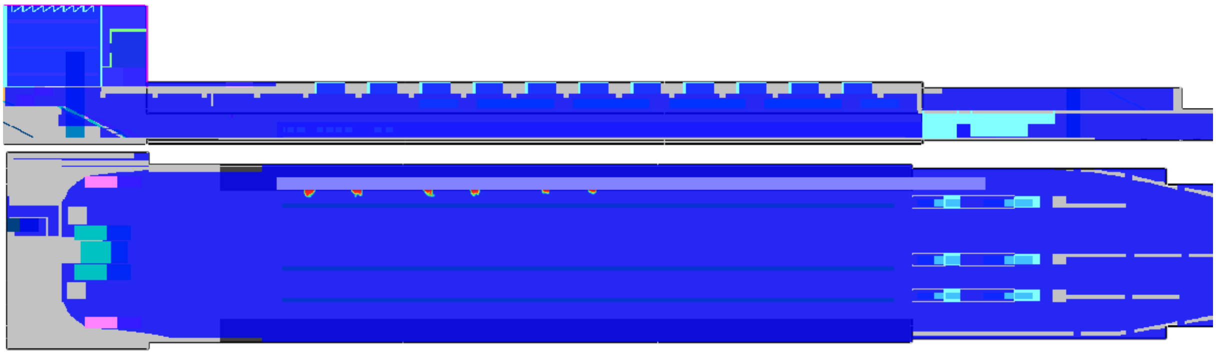


Fire Scenario 1E - Time = 960 seconds

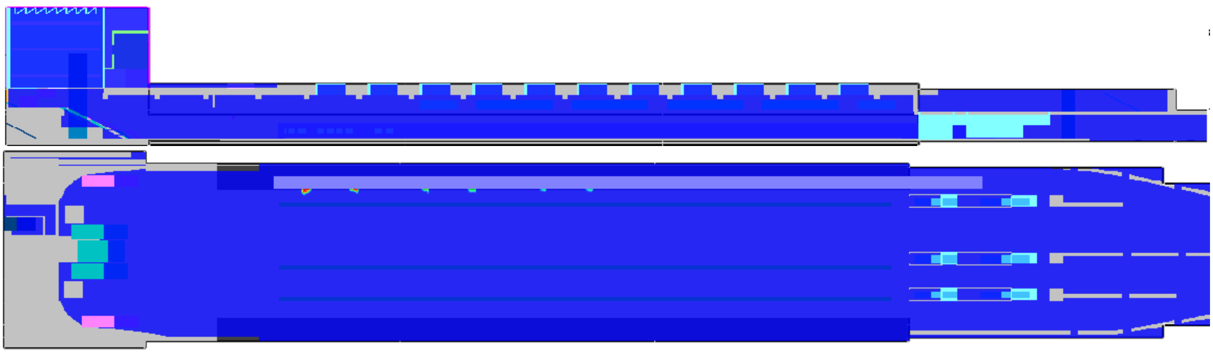
Visibility



Temperature

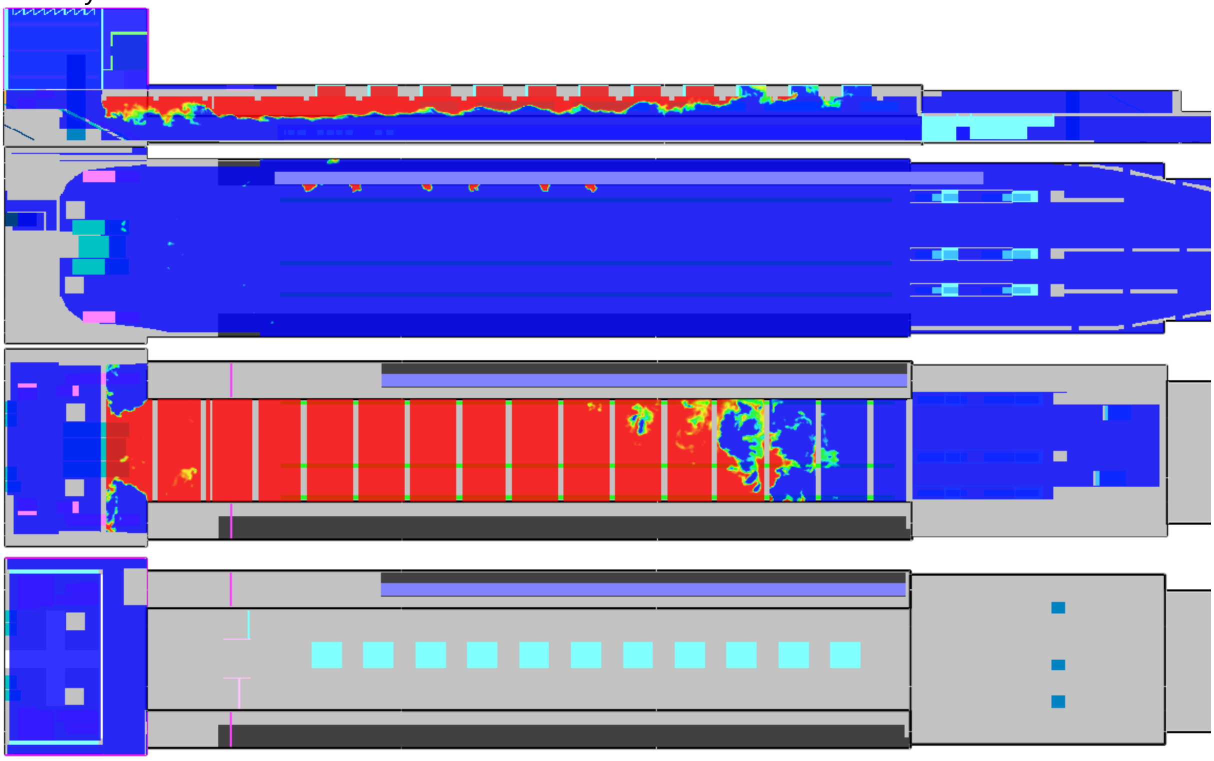


CO

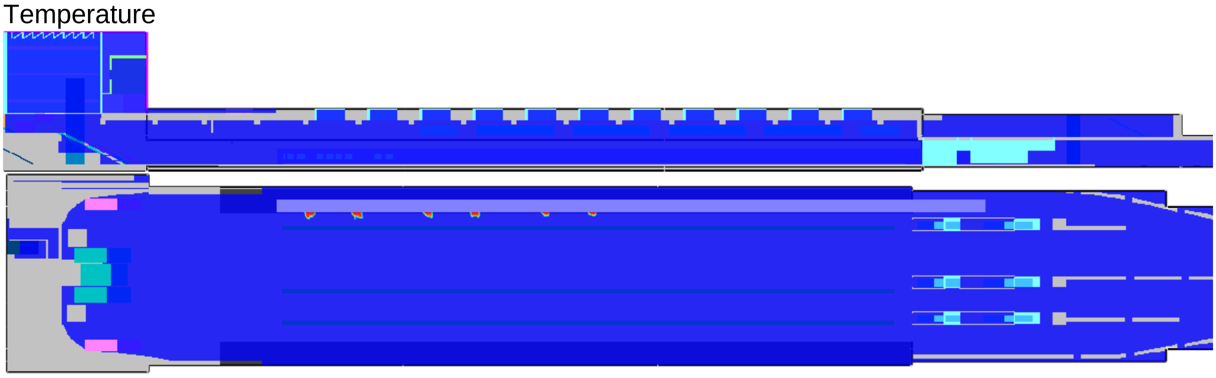


Fire Scenario 1E - Time = 1,200 seconds

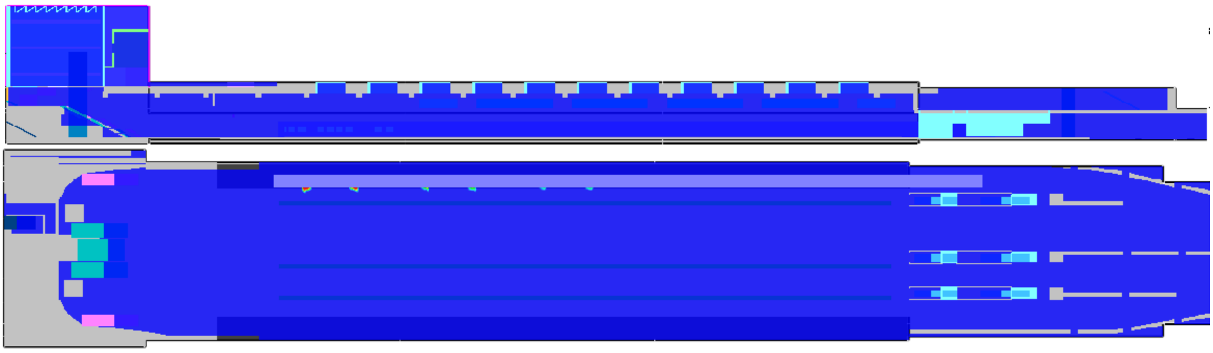
Visibility

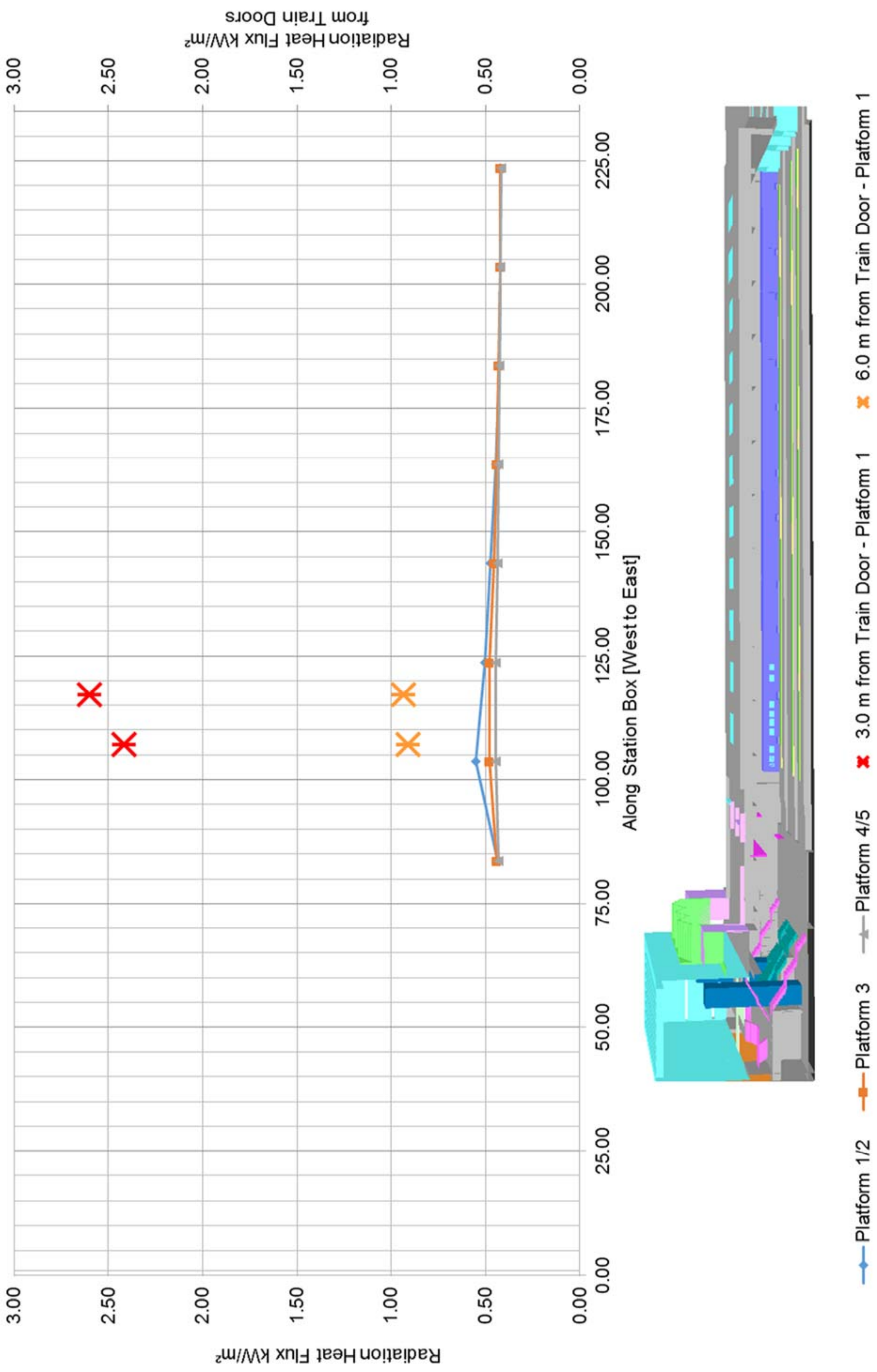


Temperature



CO

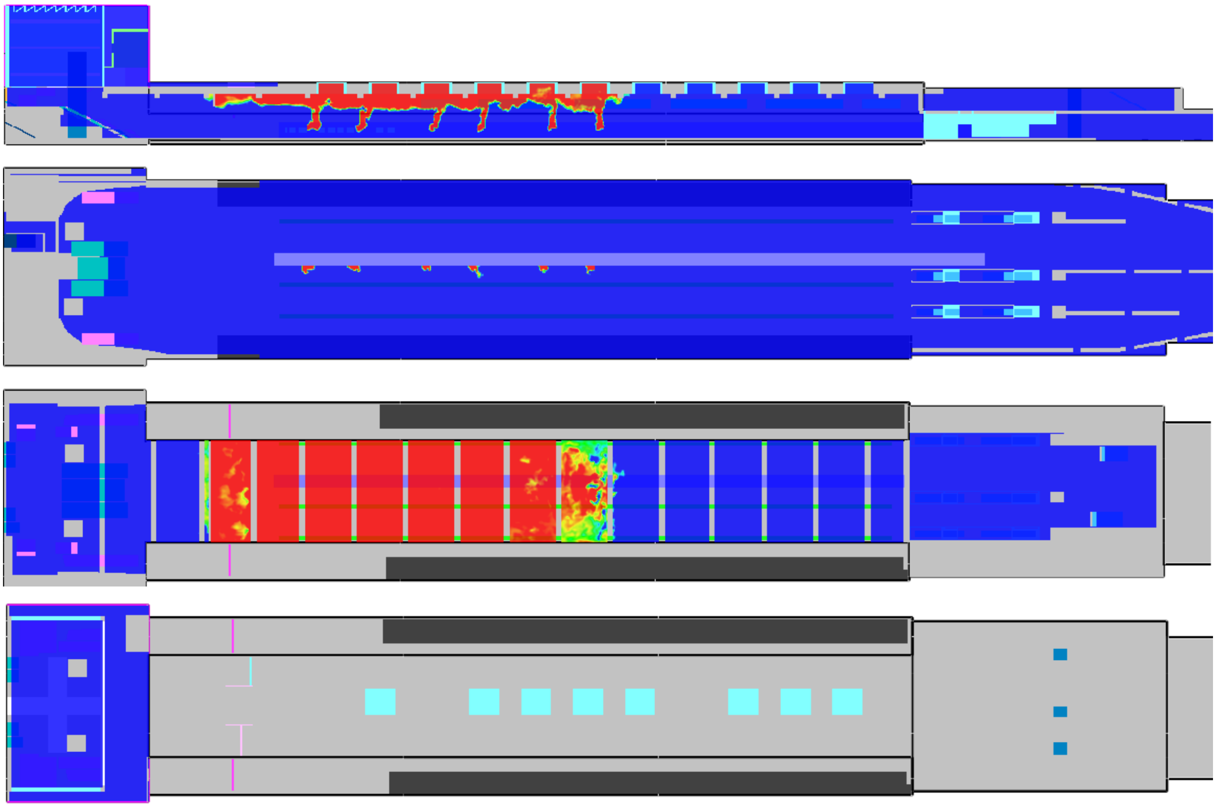




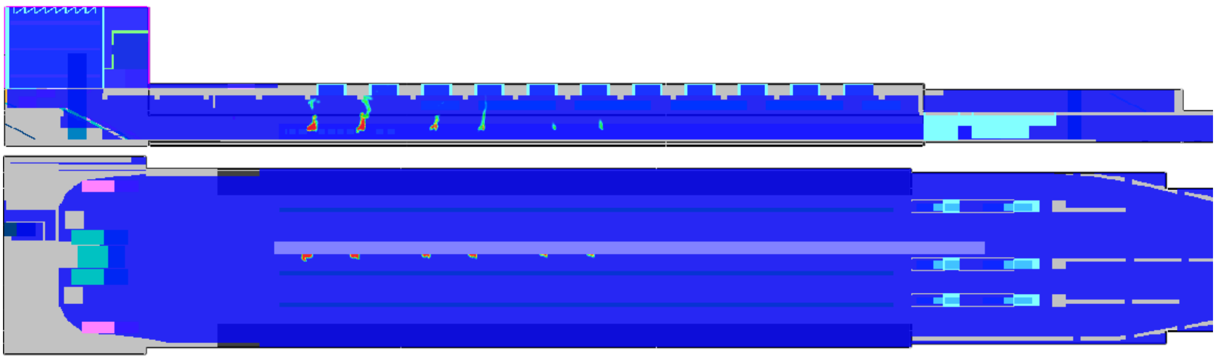
Radiation Heat Flux kW/m² from Train Doors
Radiation Heat Flux kW/m²
Along Station Box [West to East]
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Platform 1/2
Platform 3
Platform 4/5
3.0 m from Train Door - Platform 1
6.0 m from Train Door - Platform 1

Fire Scenario 2E - Time = 120 seconds

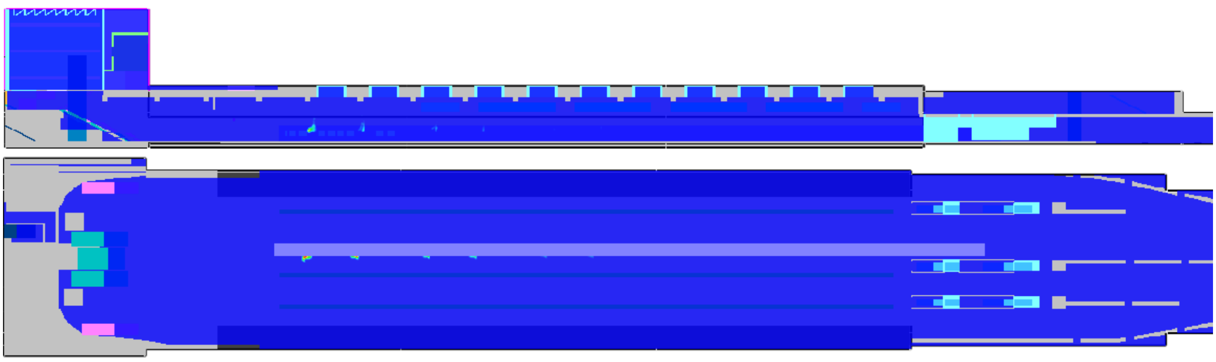
Visibility



Temperature

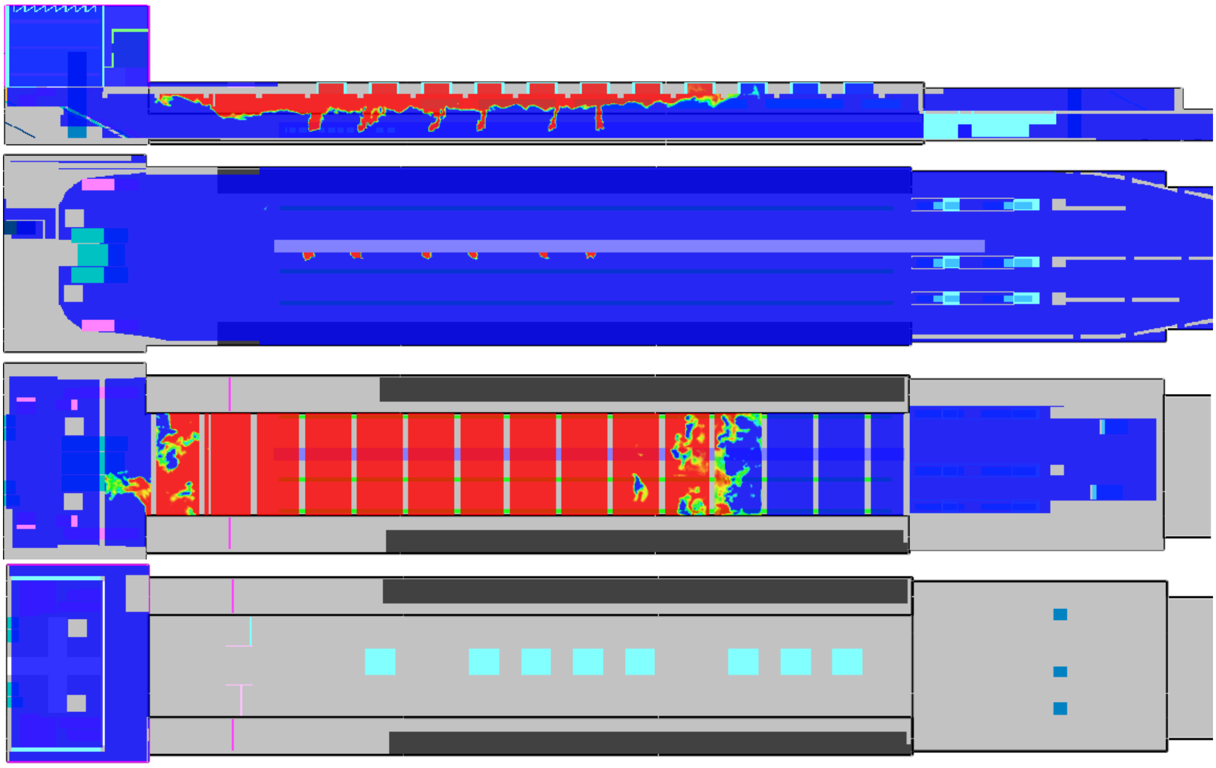


CO

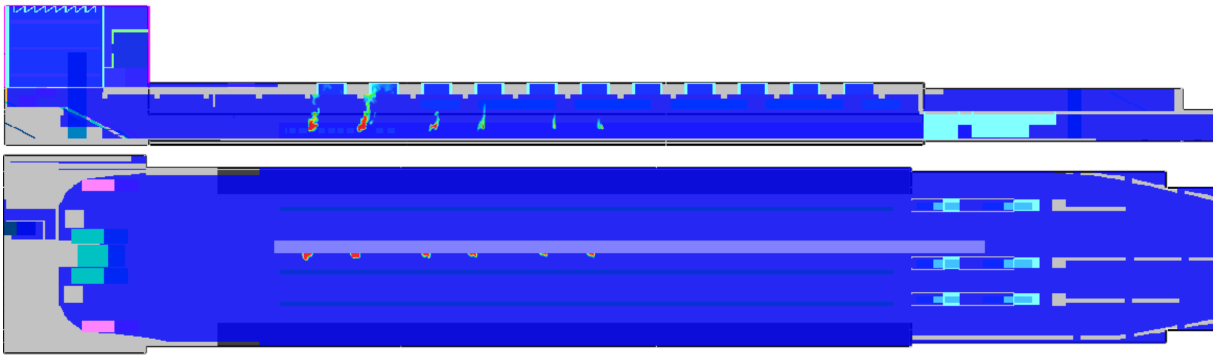


Fire Scenario 2E - Time = 240 seconds

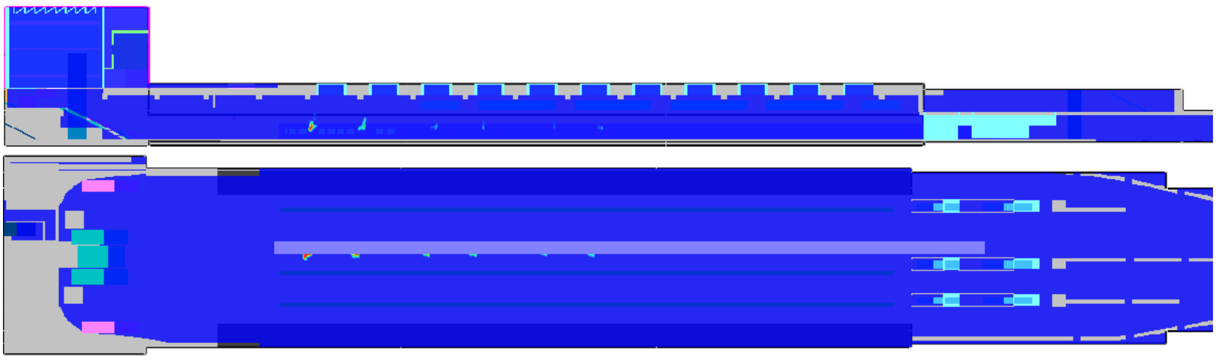
Visibility



Temperature

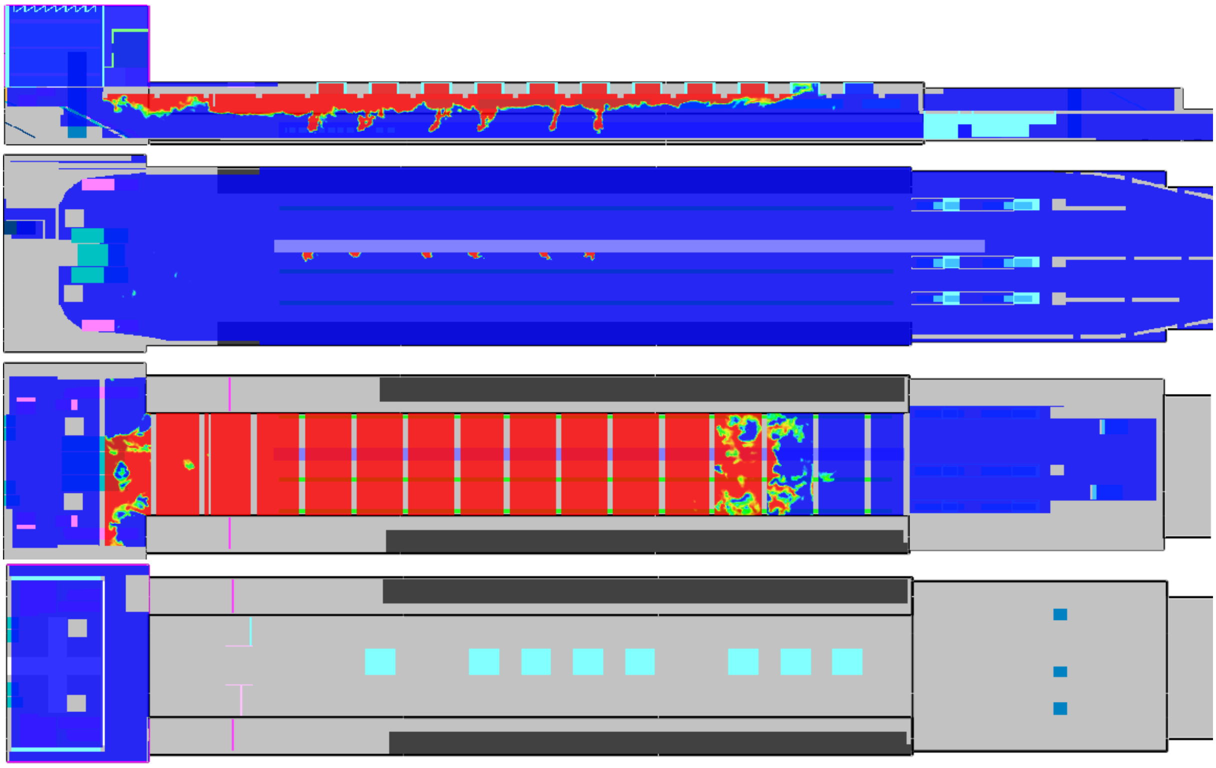


CO

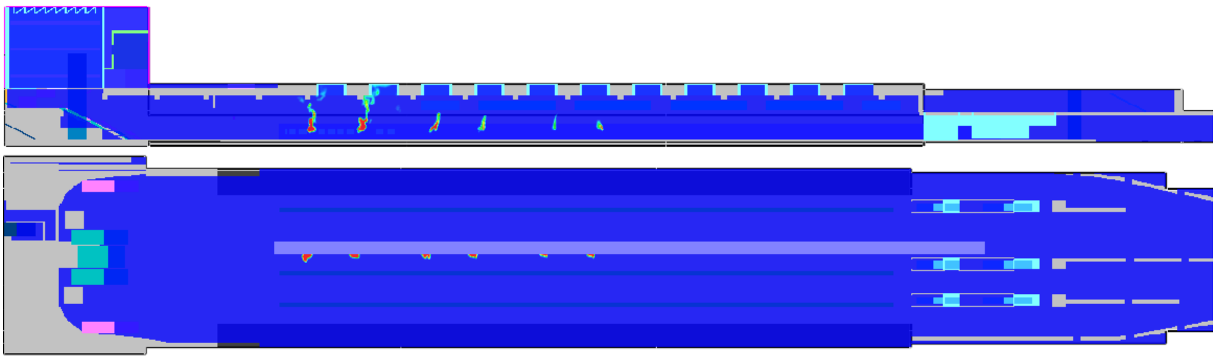


Fire Scenario 2E - Time = 360 seconds

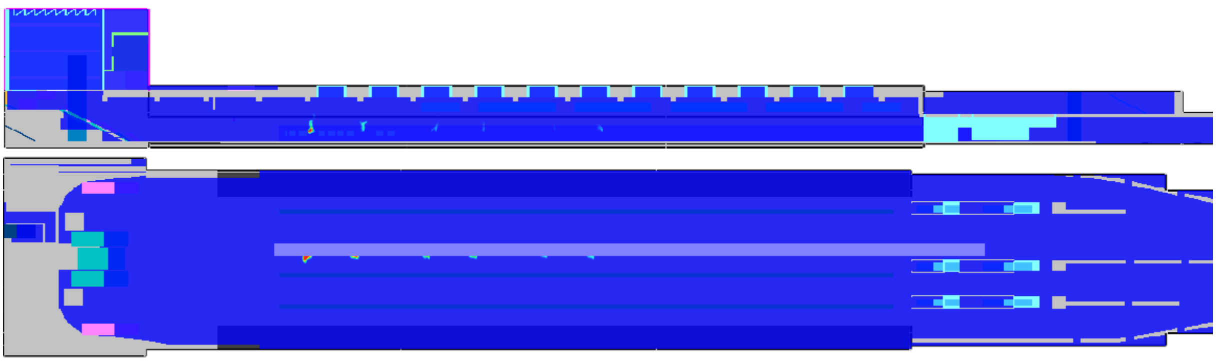
Visibility



Temperature

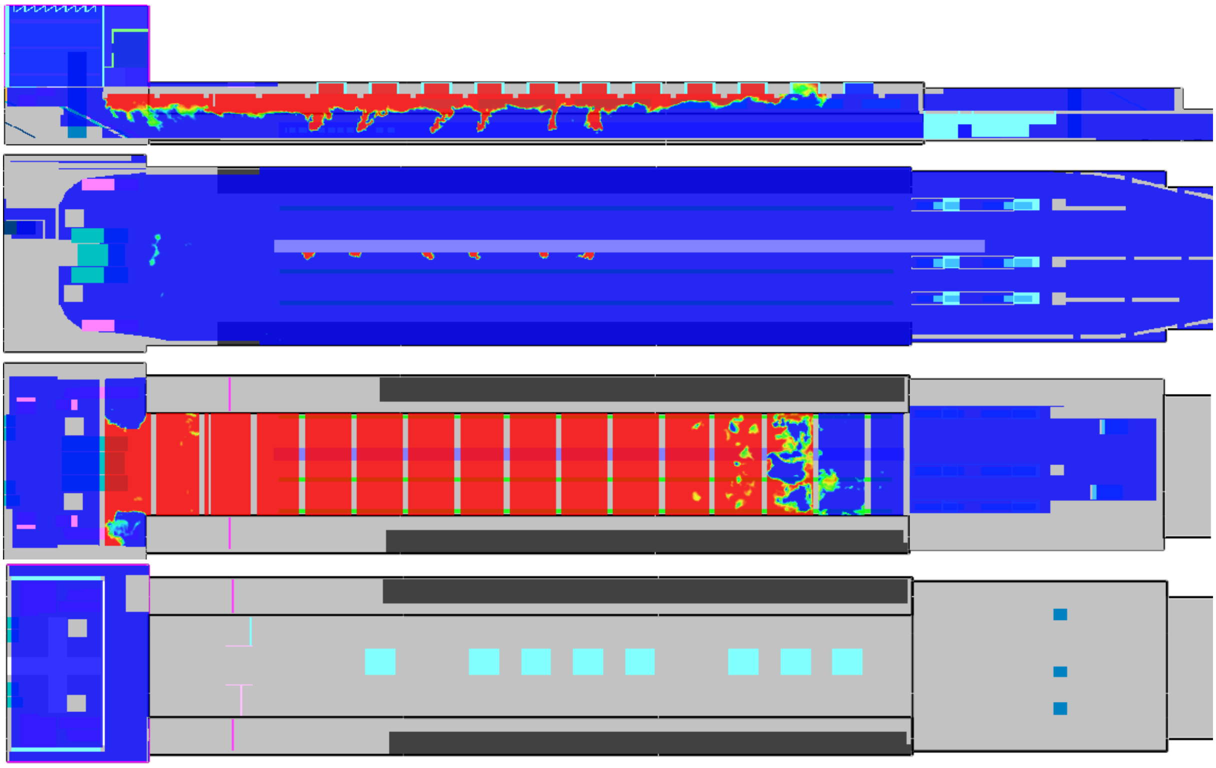


CO

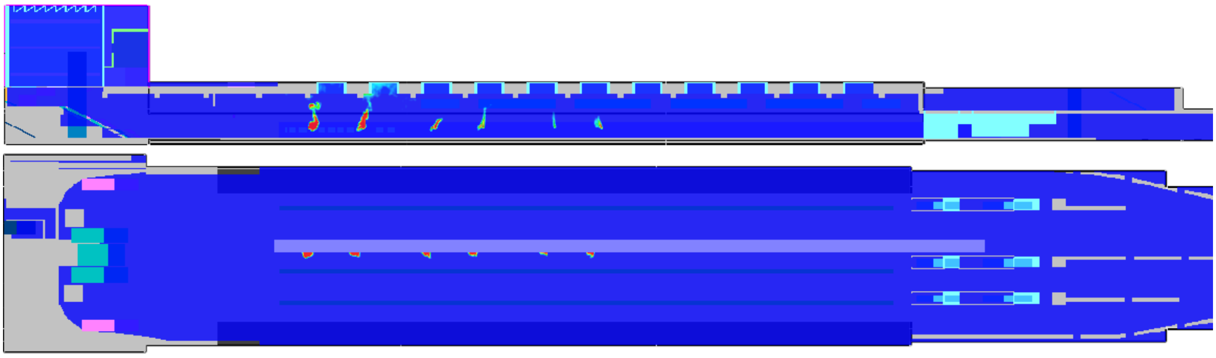


Fire Scenario 2E - Time = 480 seconds

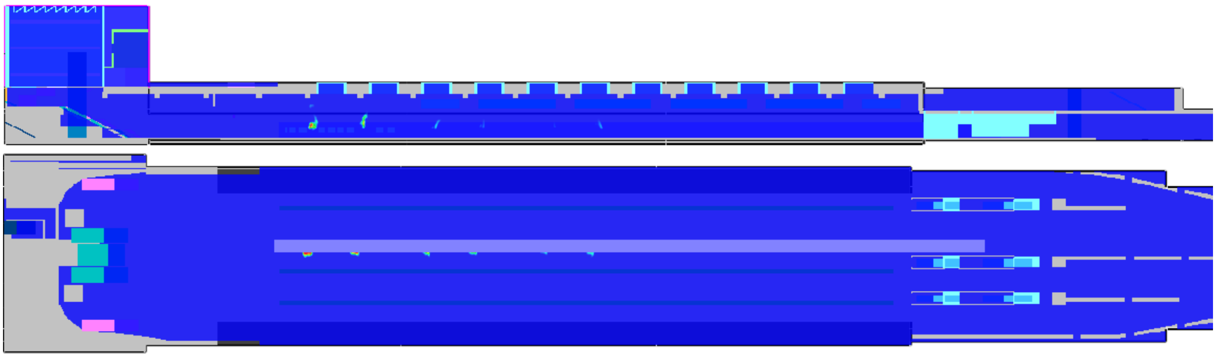
Visibility



Temperature

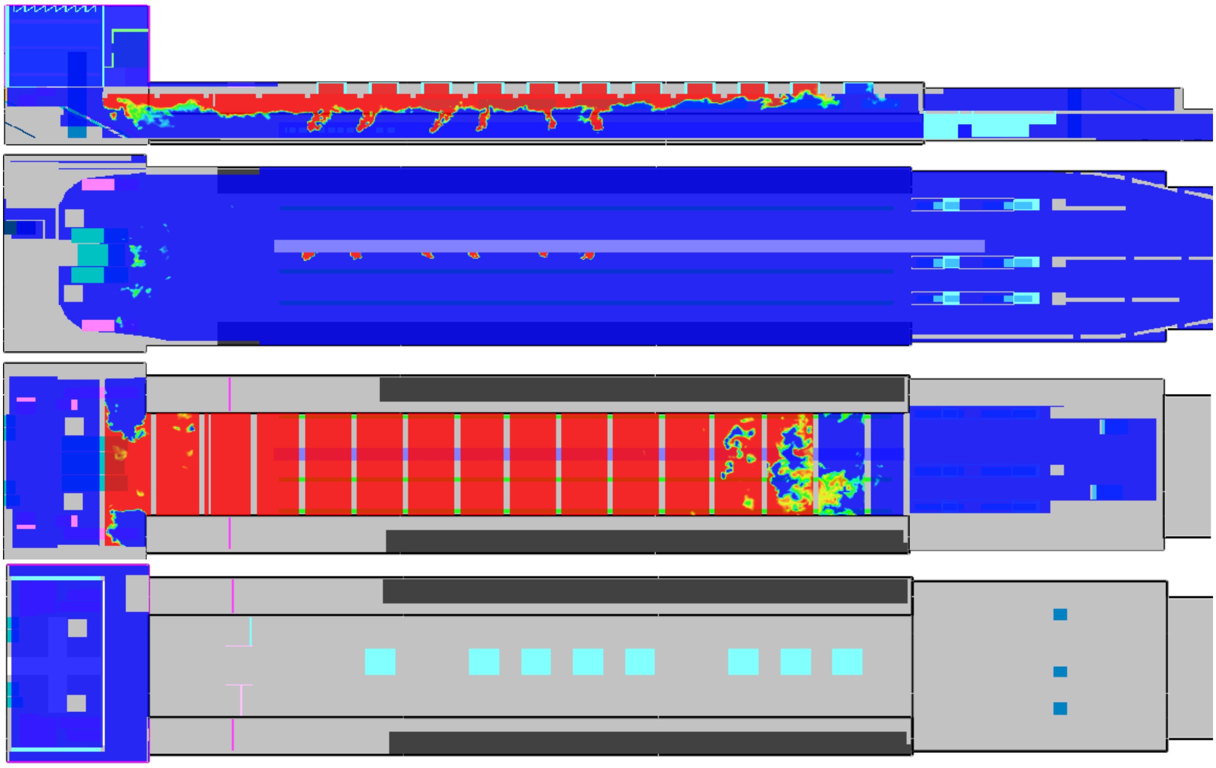


CO

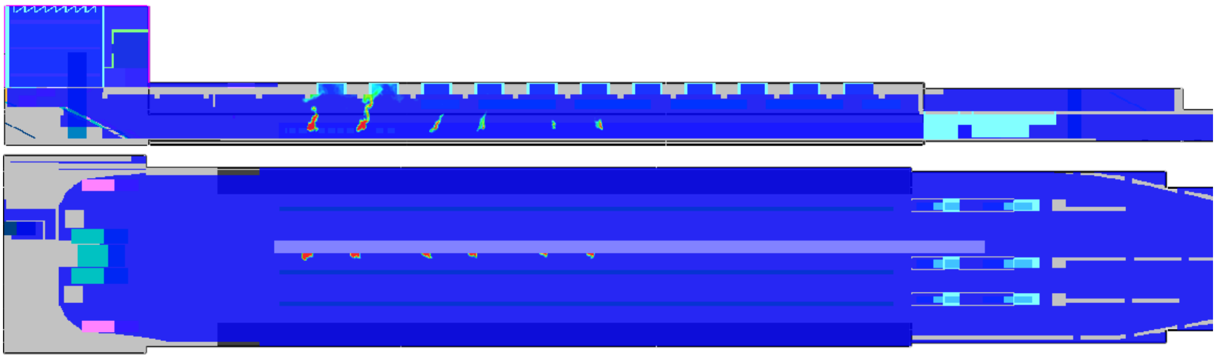


Fire Scenario 2E - Time = 600 seconds

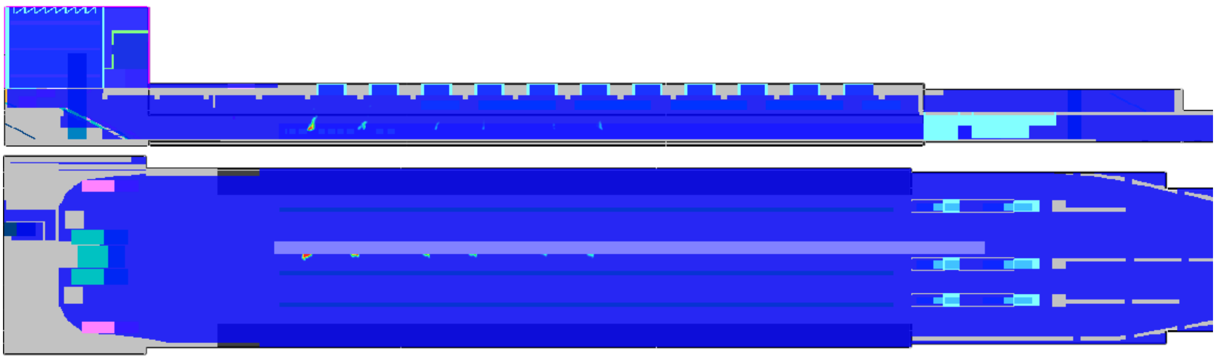
Visibility



Temperature

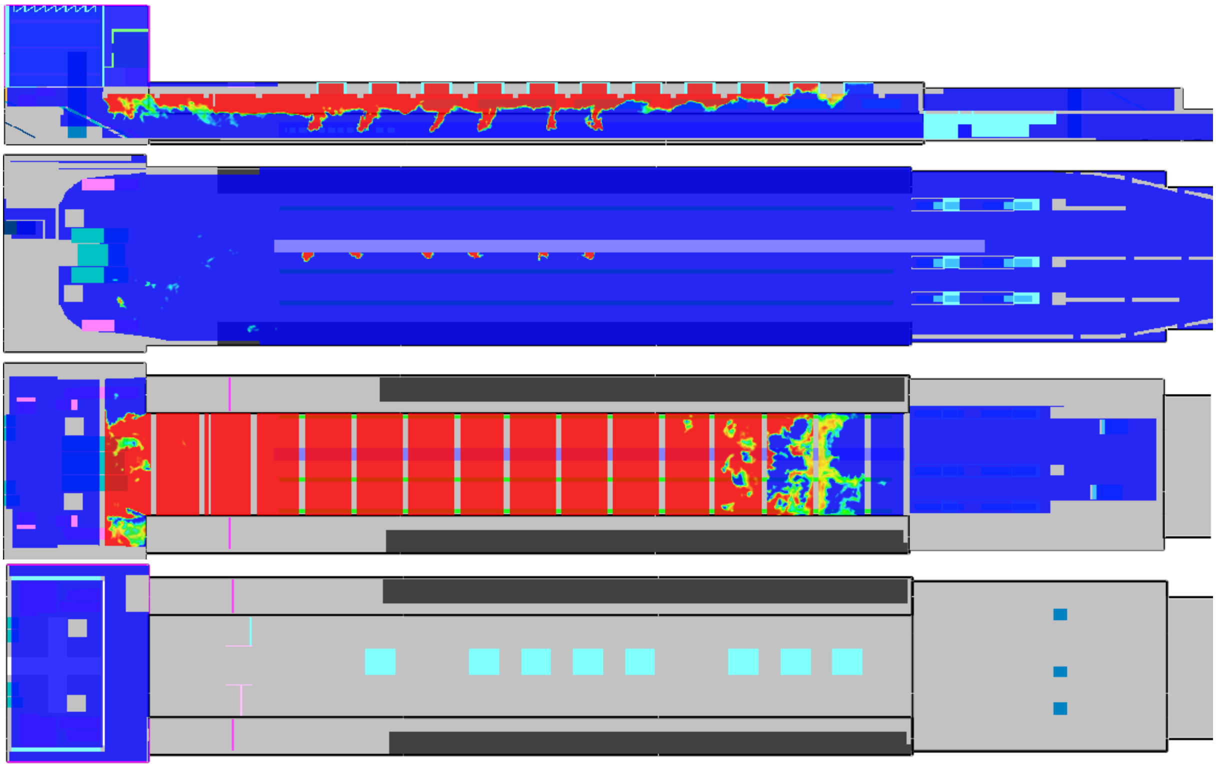


CO

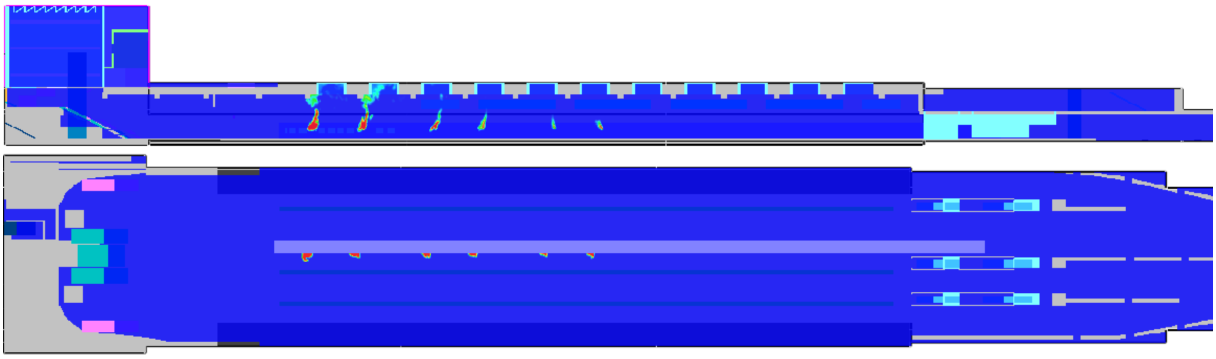


Fire Scenario 2E - Time = 720 seconds

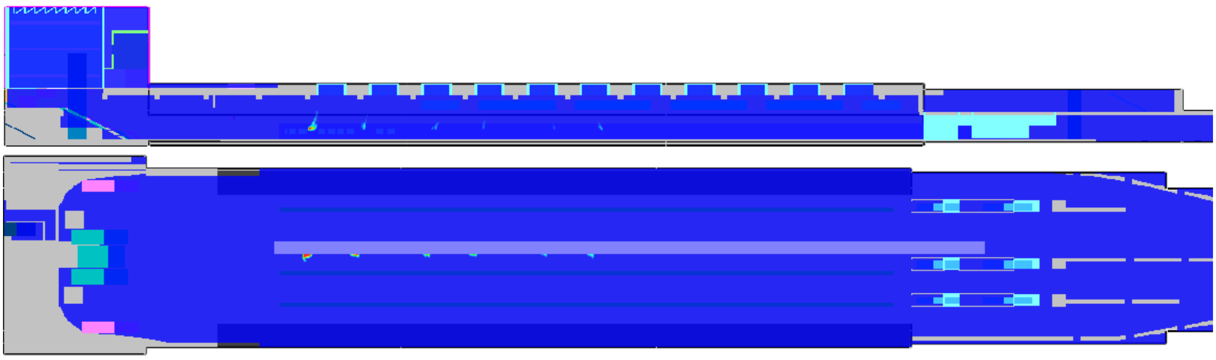
Visibility



Temperature

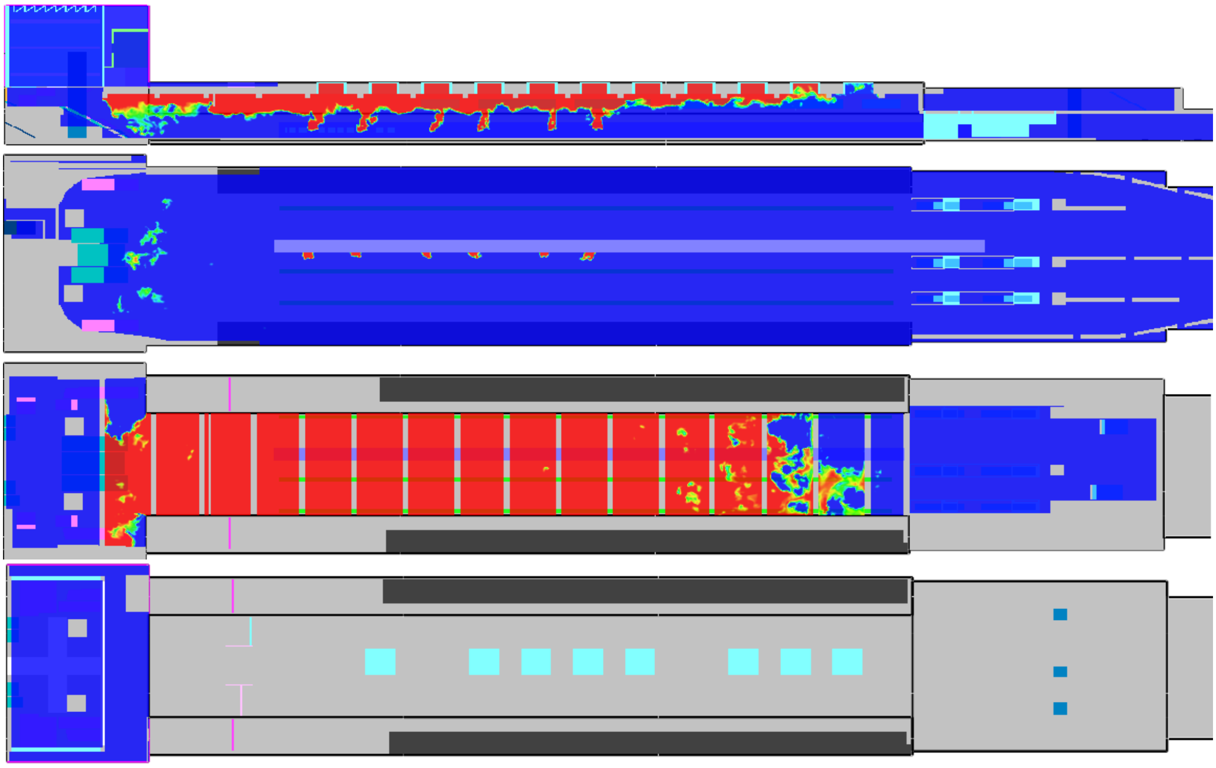


CO

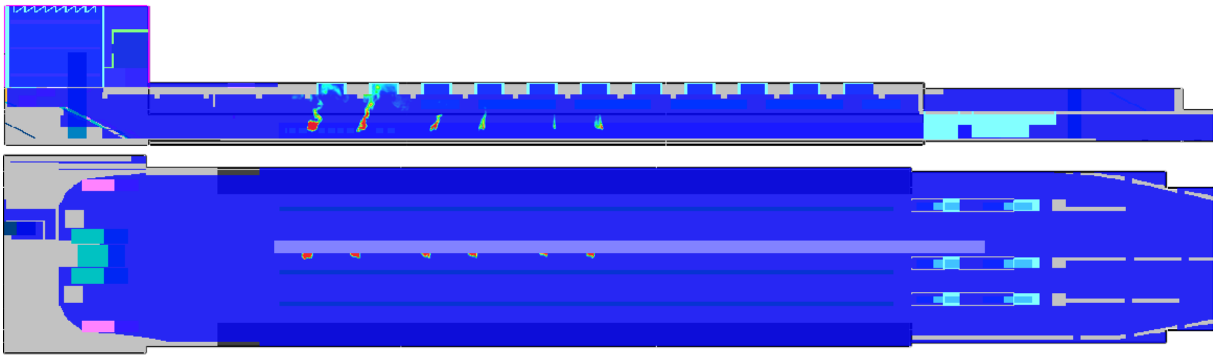


Fire Scenario 2E - Time = 840 seconds

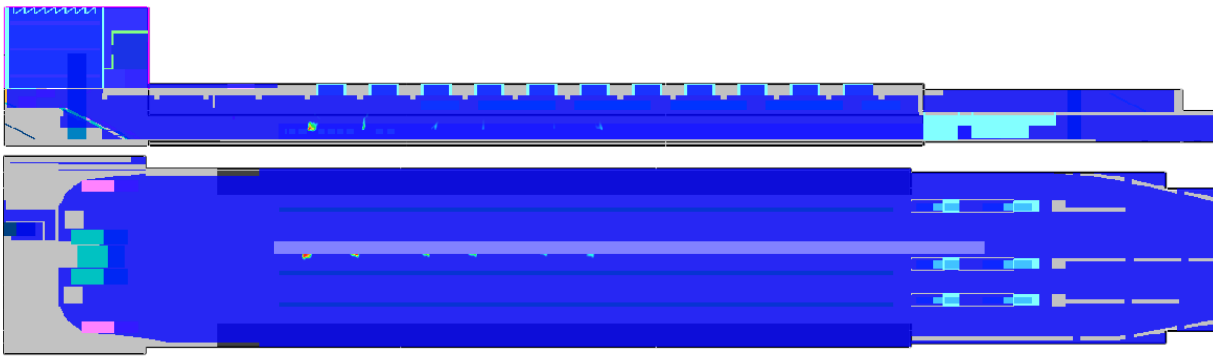
Visibility



Temperature

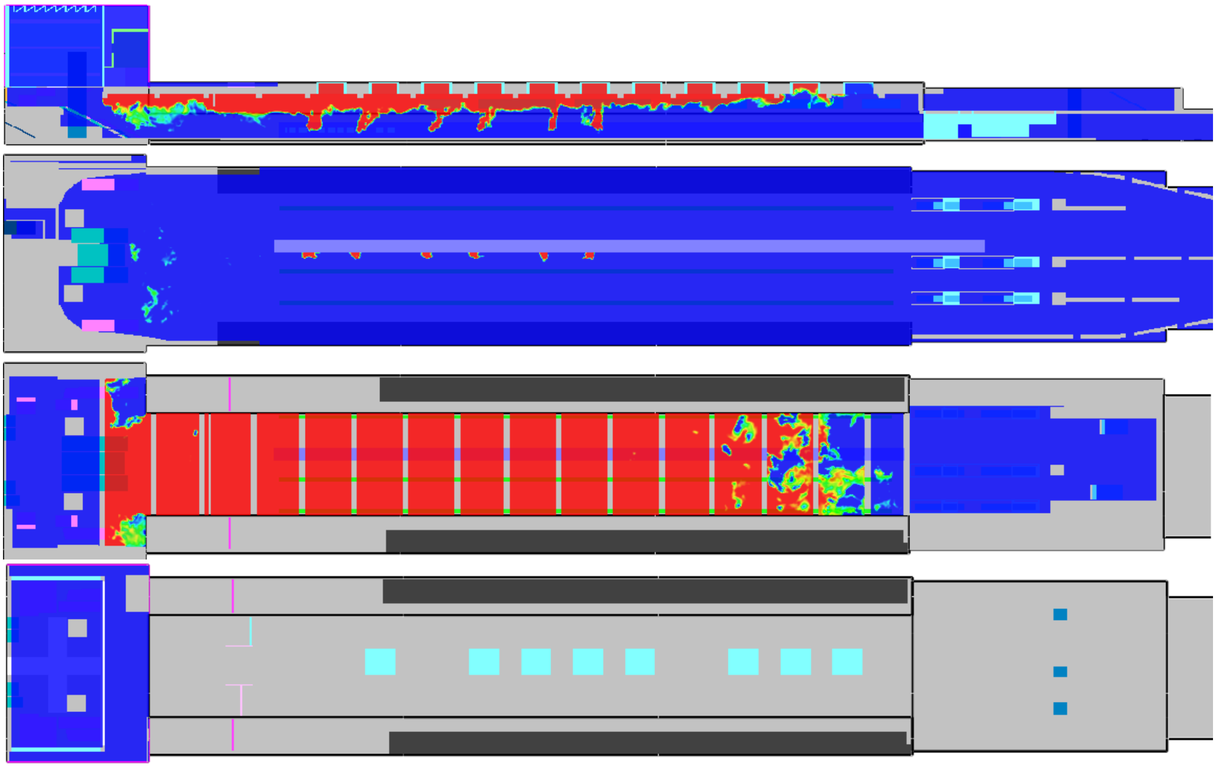


CO

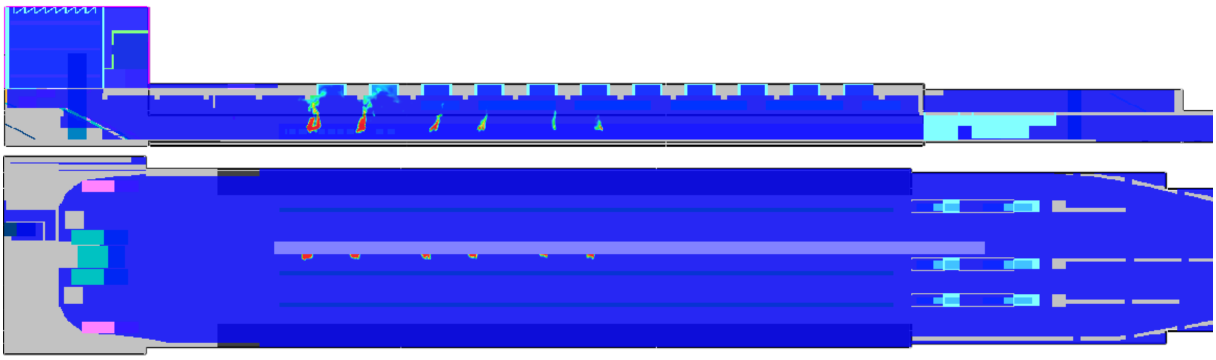


Fire Scenario 2E - Time = 960 seconds

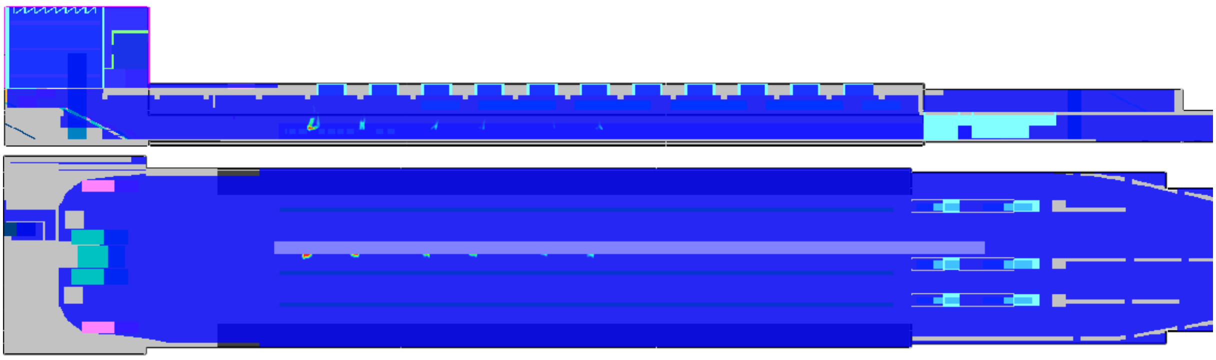
Visibility



Temperature

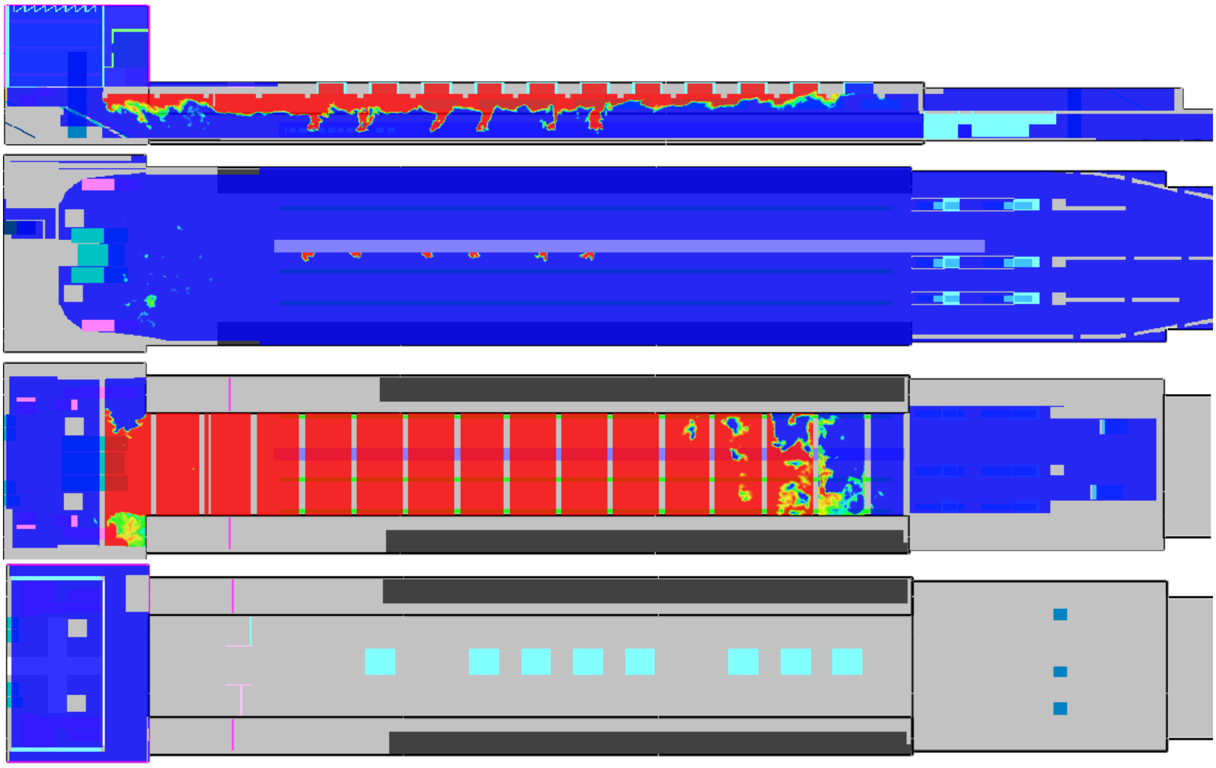


CO

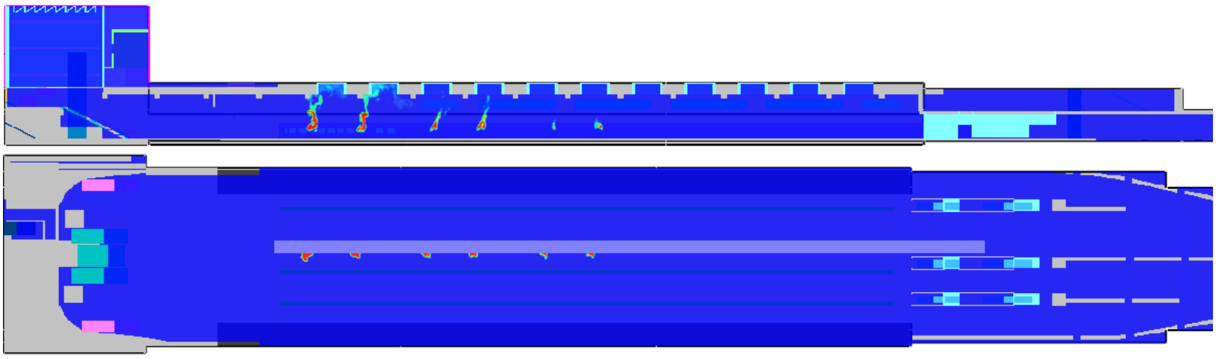


Fire Scenario 2E - Time = 1,200 seconds

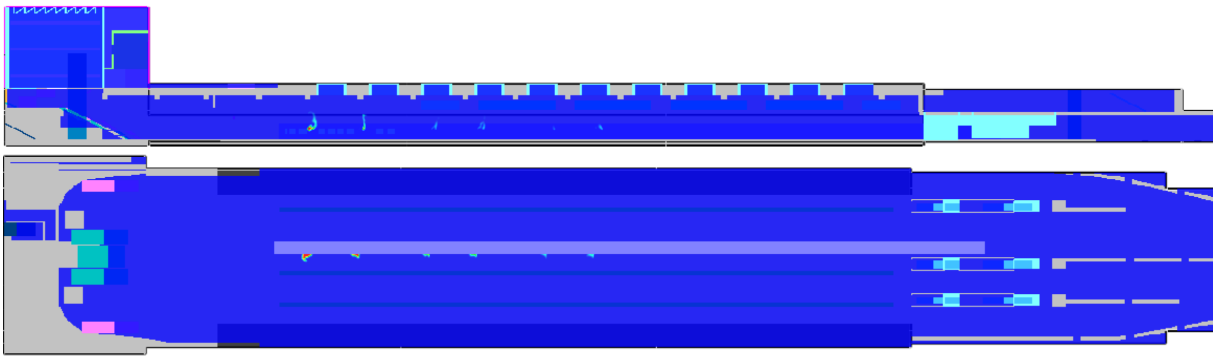
Visibility

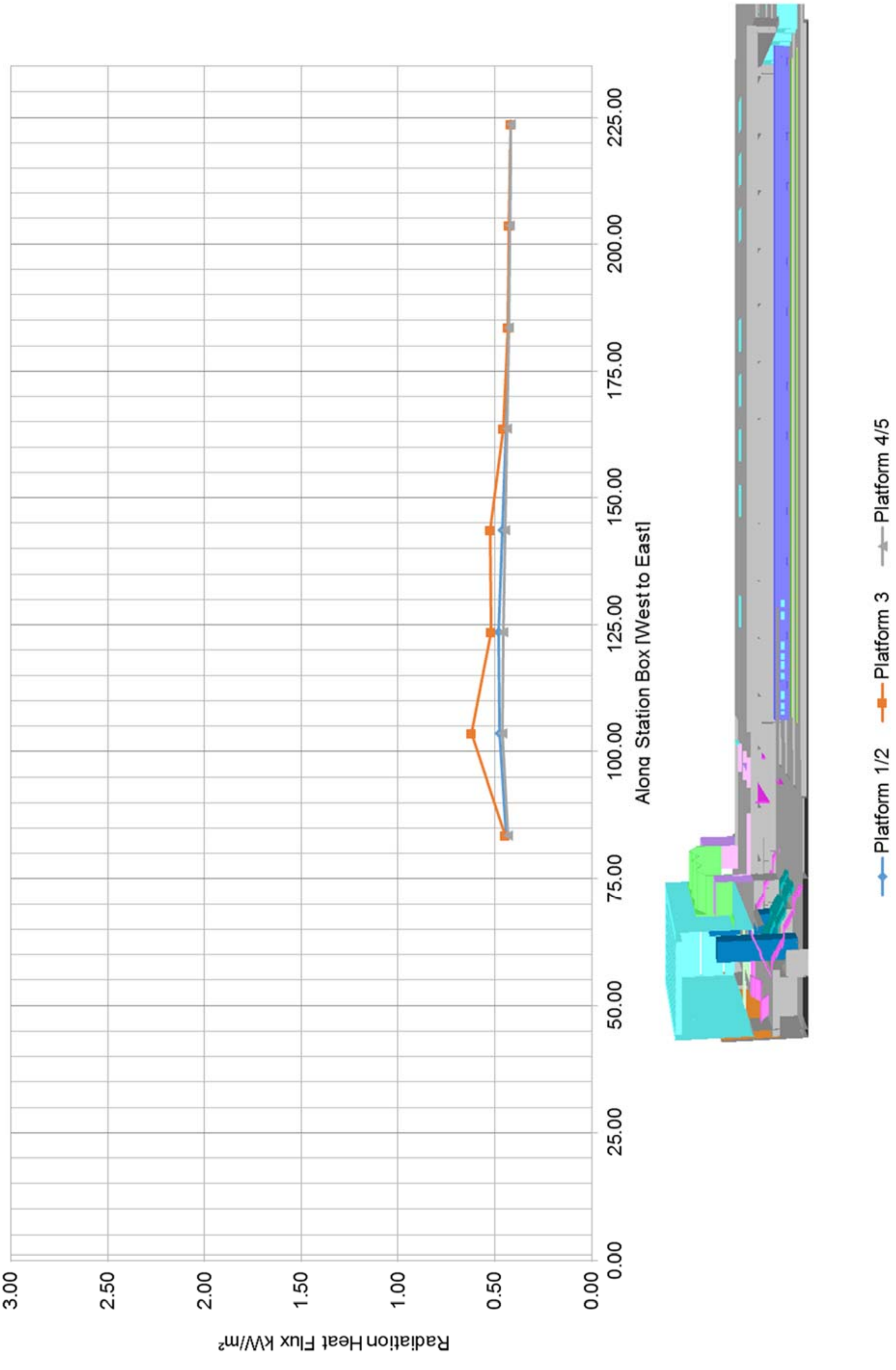


Temperature



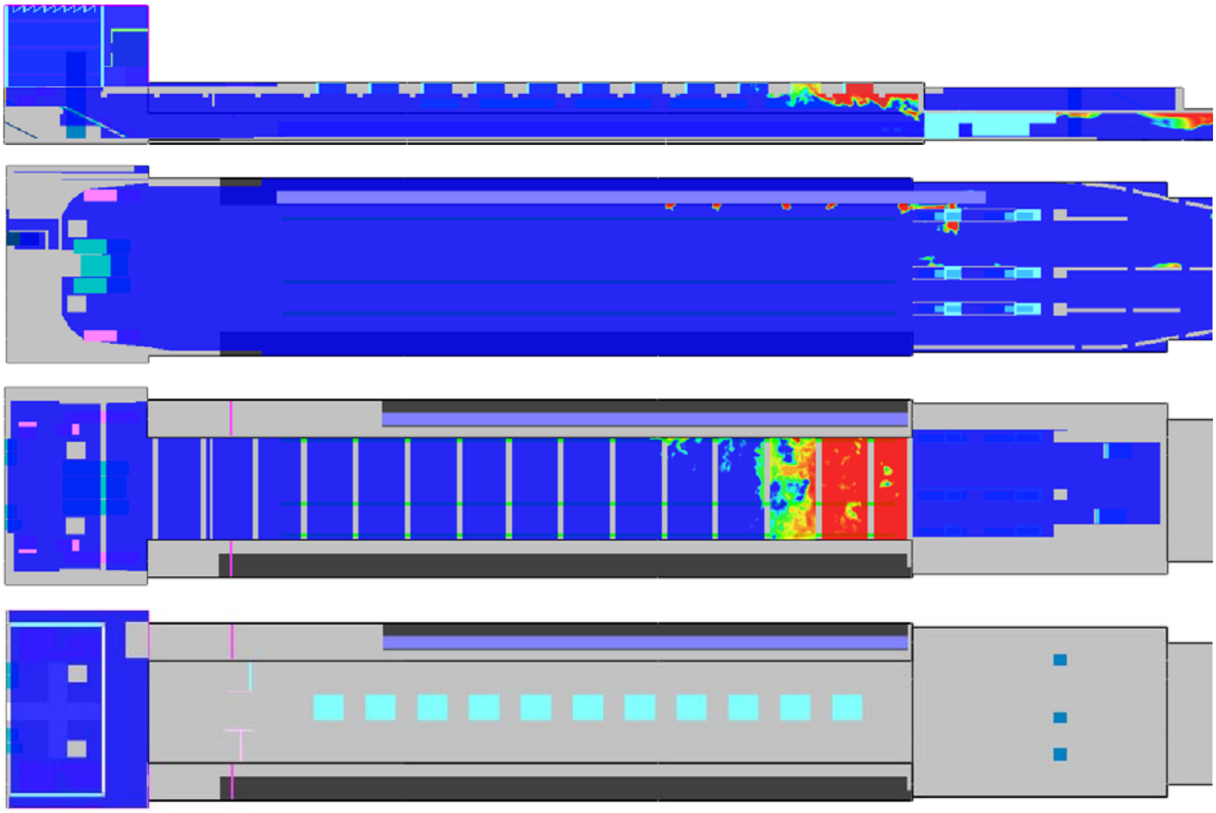
CO



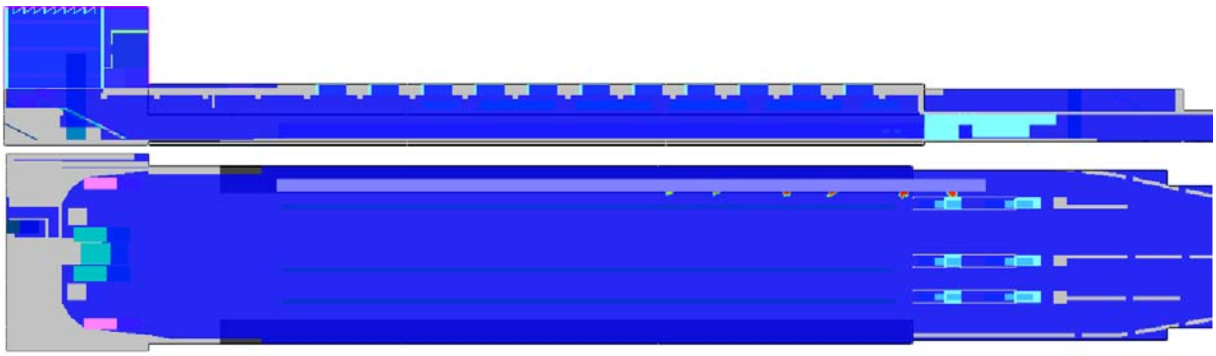

Radiation Heat Flux kW/m²
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
Along Station Box [West to East]
Platform 1/2
Platform 3
Platform 4/5

Fire Scenario 3E - Time = 120 seconds

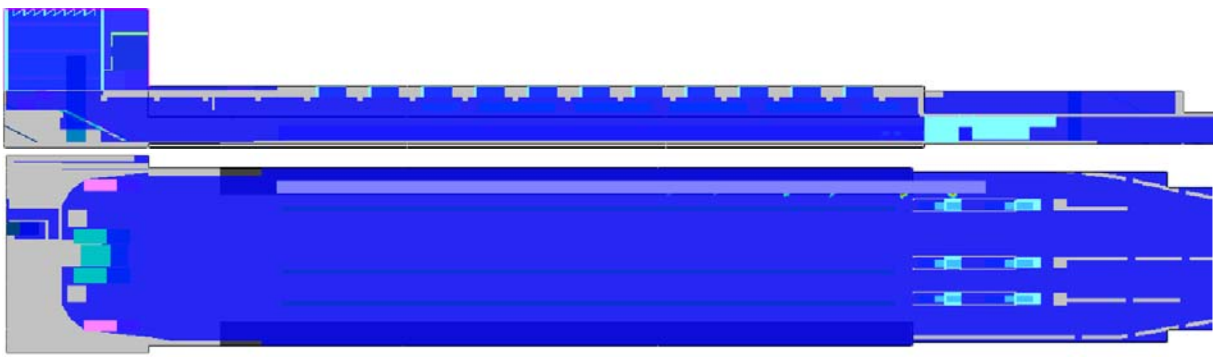
Visibility



Temperature

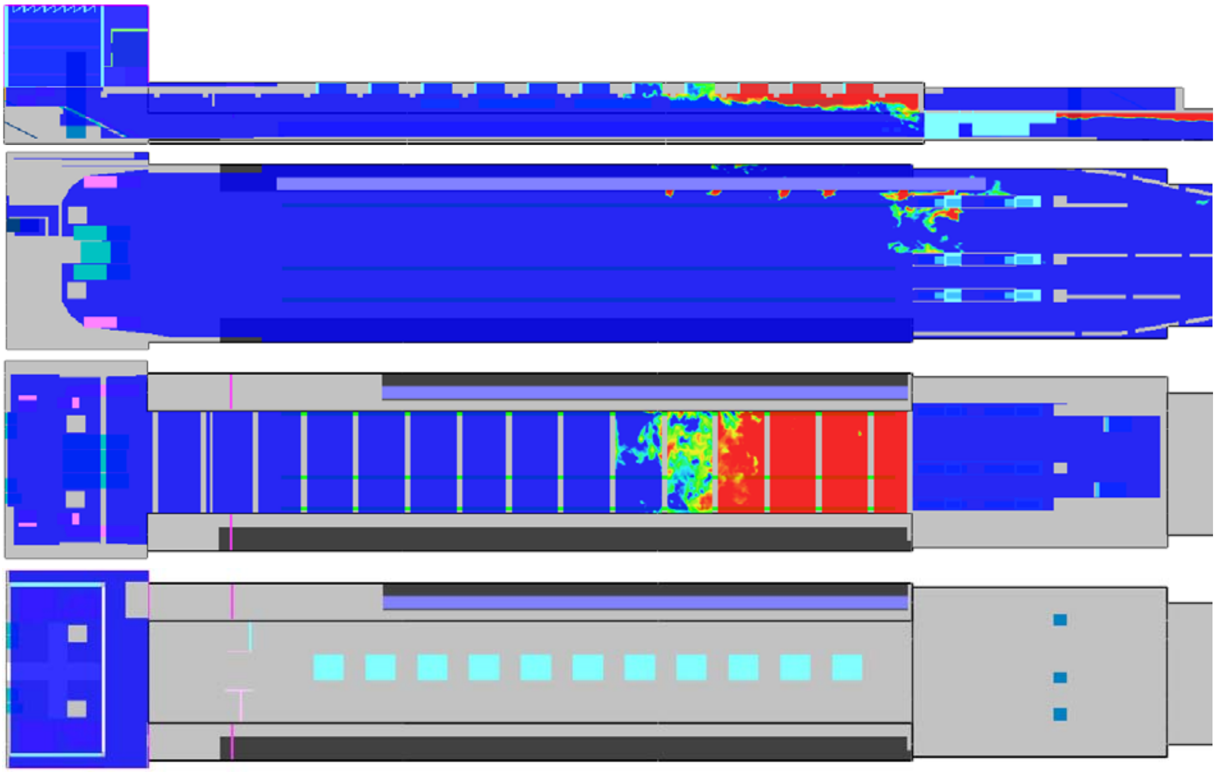


CO

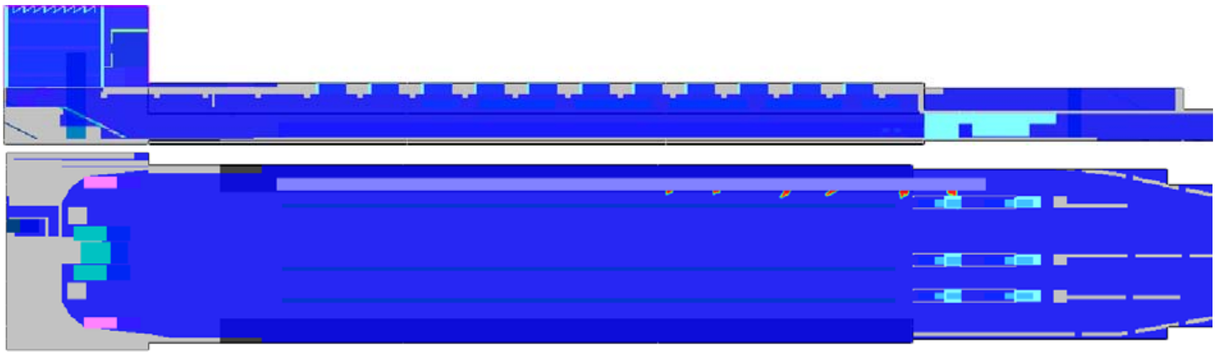


Fire Scenario 3E - Time = 240 seconds

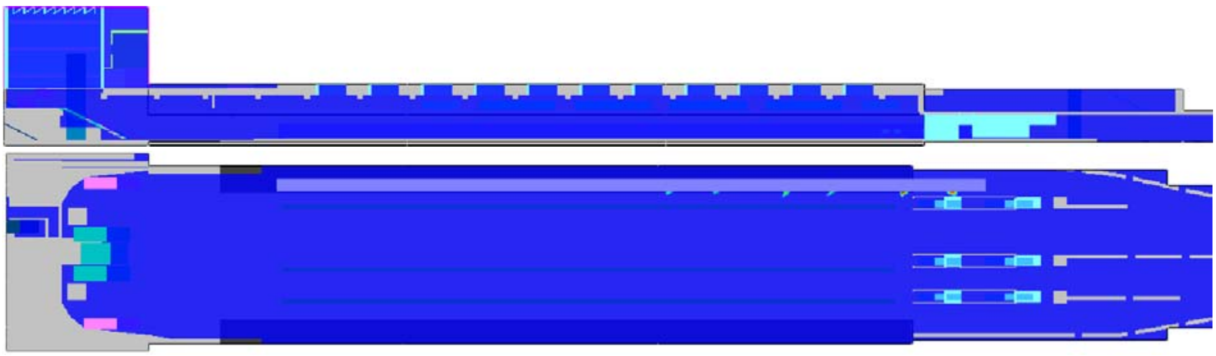
Visibility



Temperature

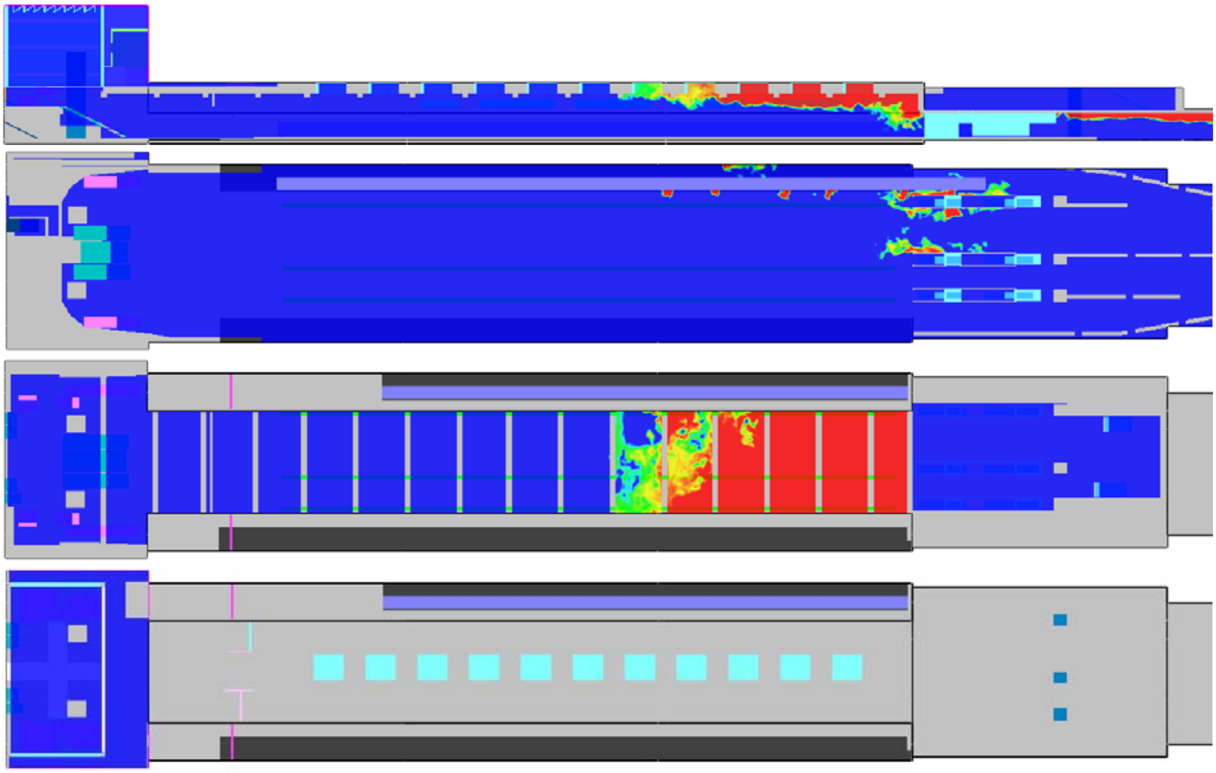


CO

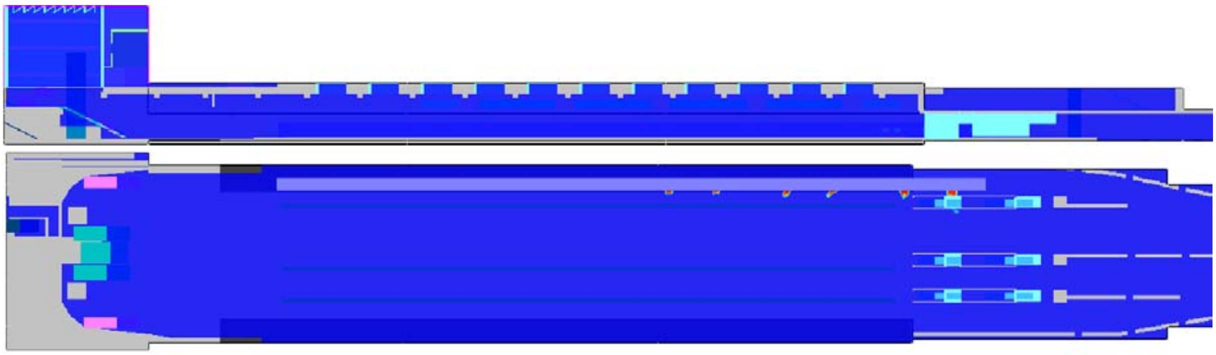


Fire Scenario 3E - Time = 360 seconds

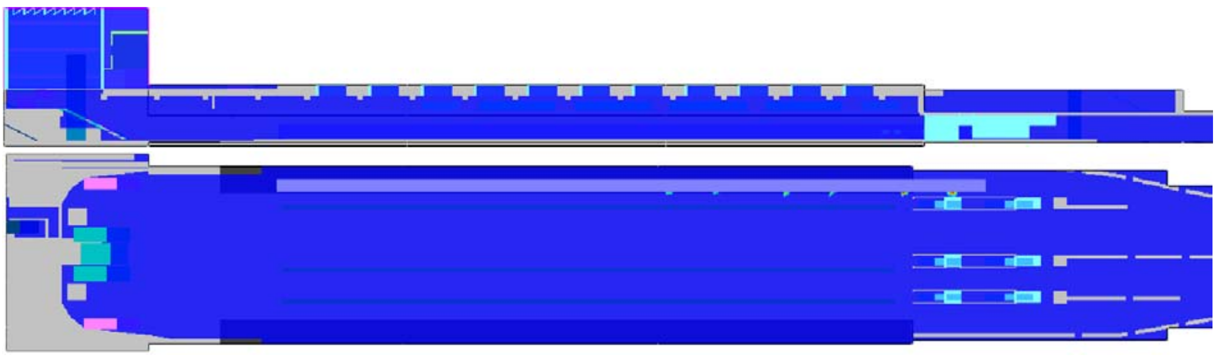
Visibility



Temperature

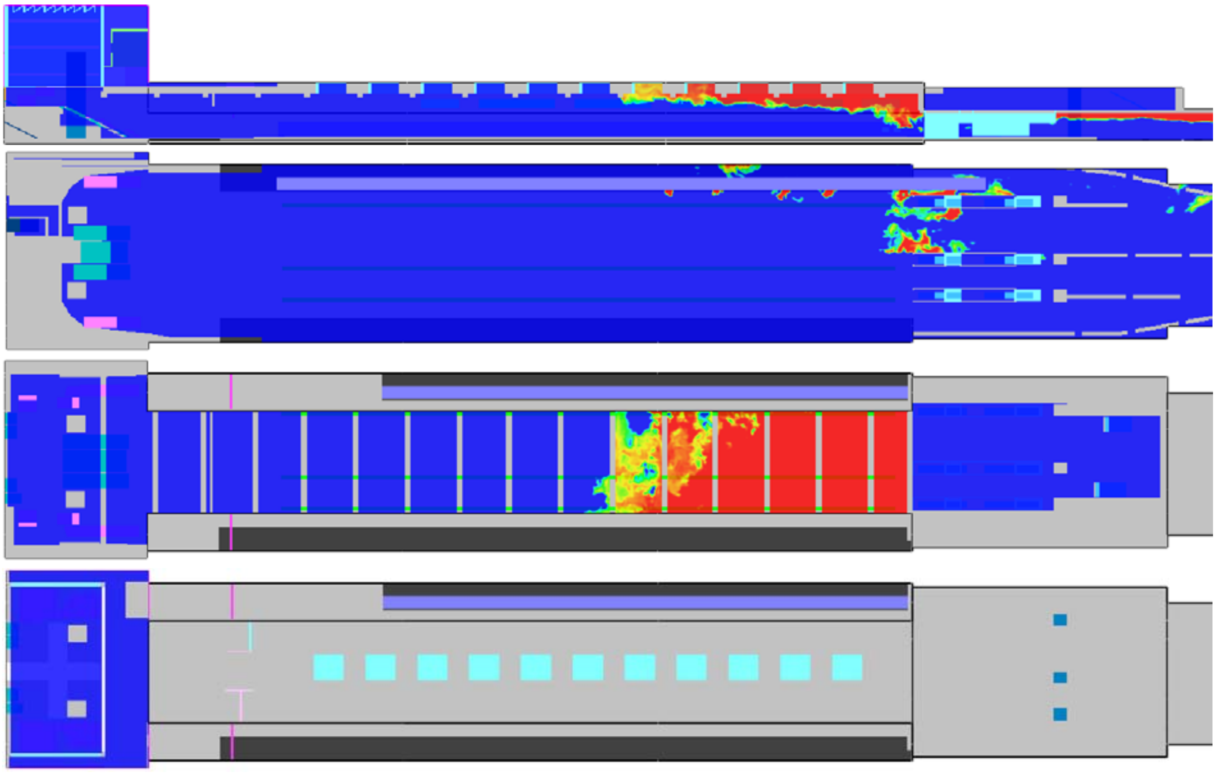


CO

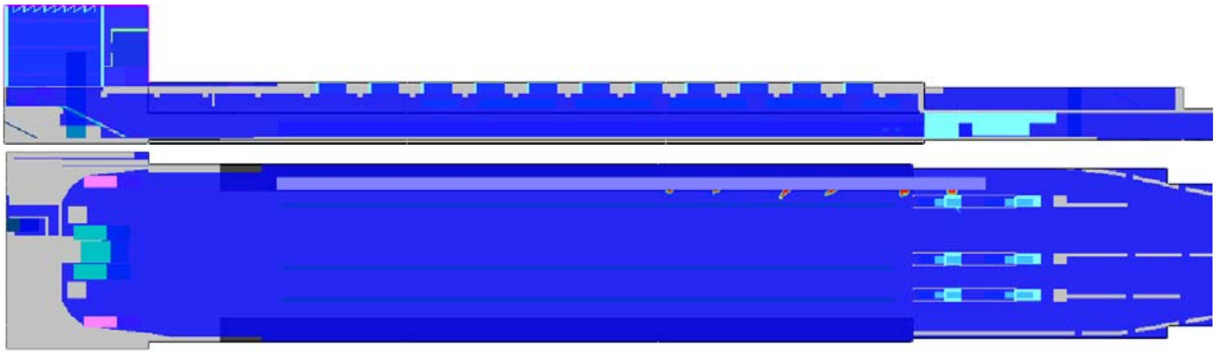


Fire Scenario 3E - Time = 480 seconds

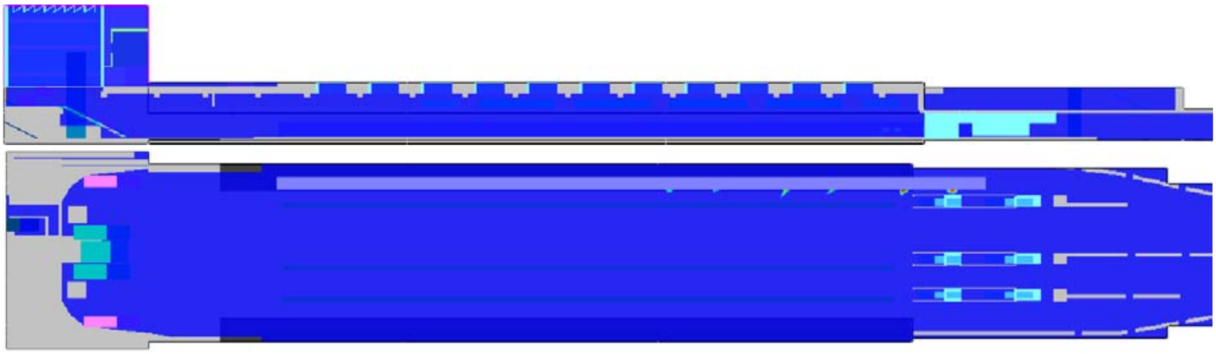
Visibility



Temperature

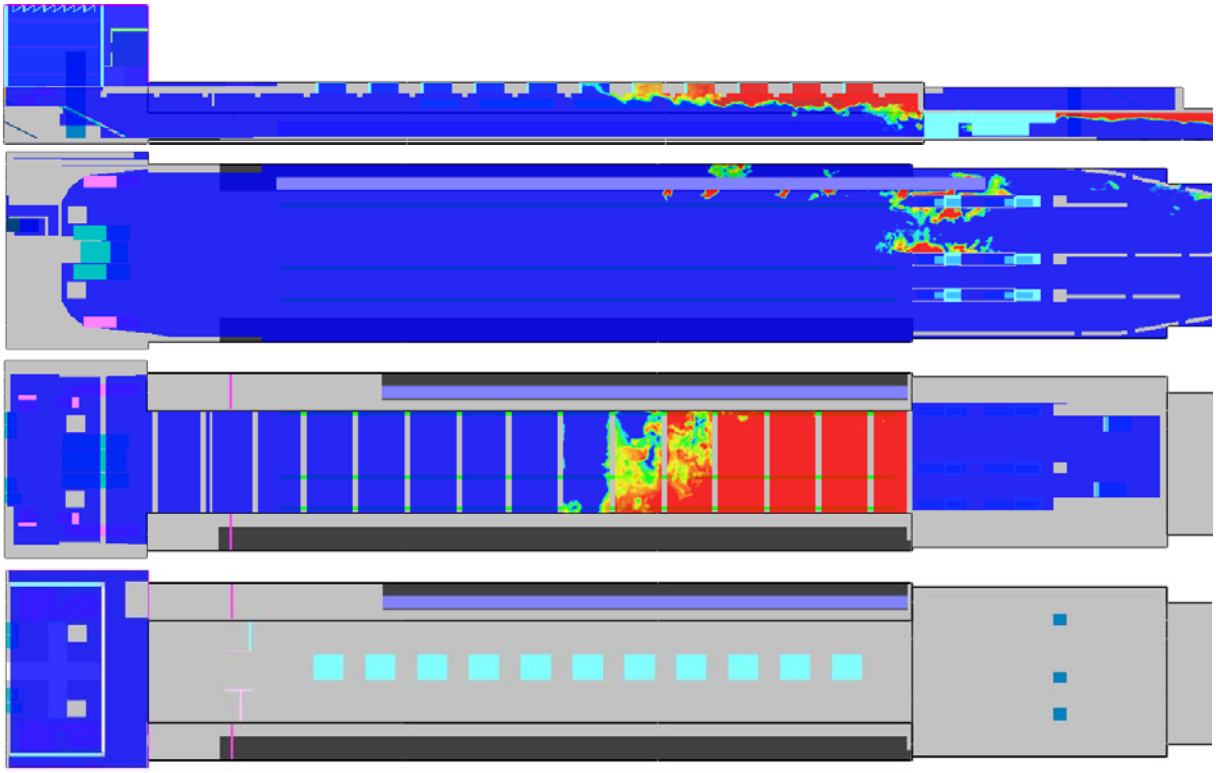


CO

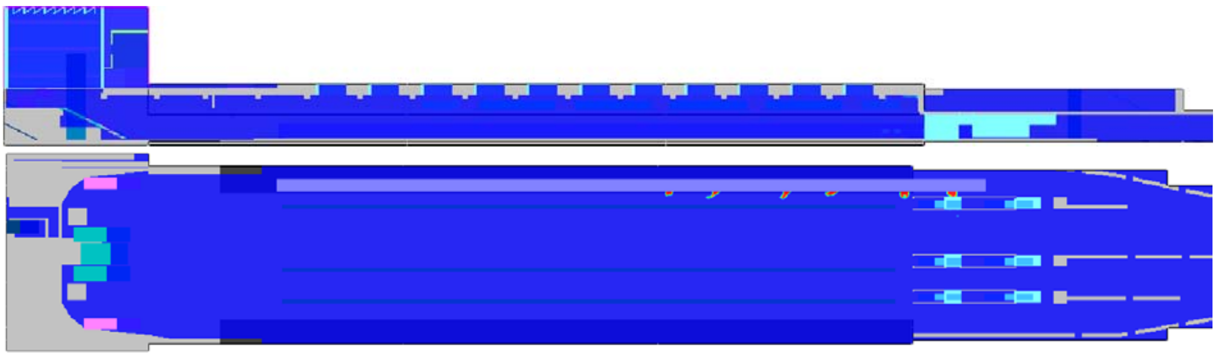


Fire Scenario 3E - Time = 600 seconds

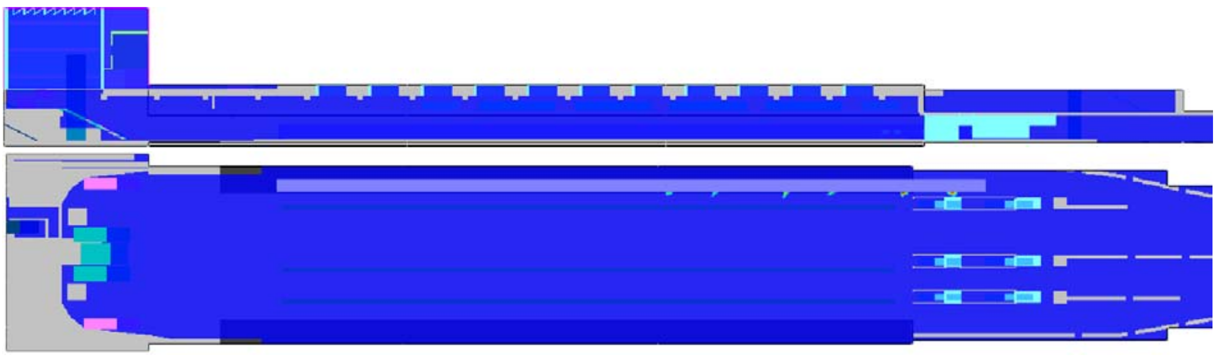
Visibility



Temperature

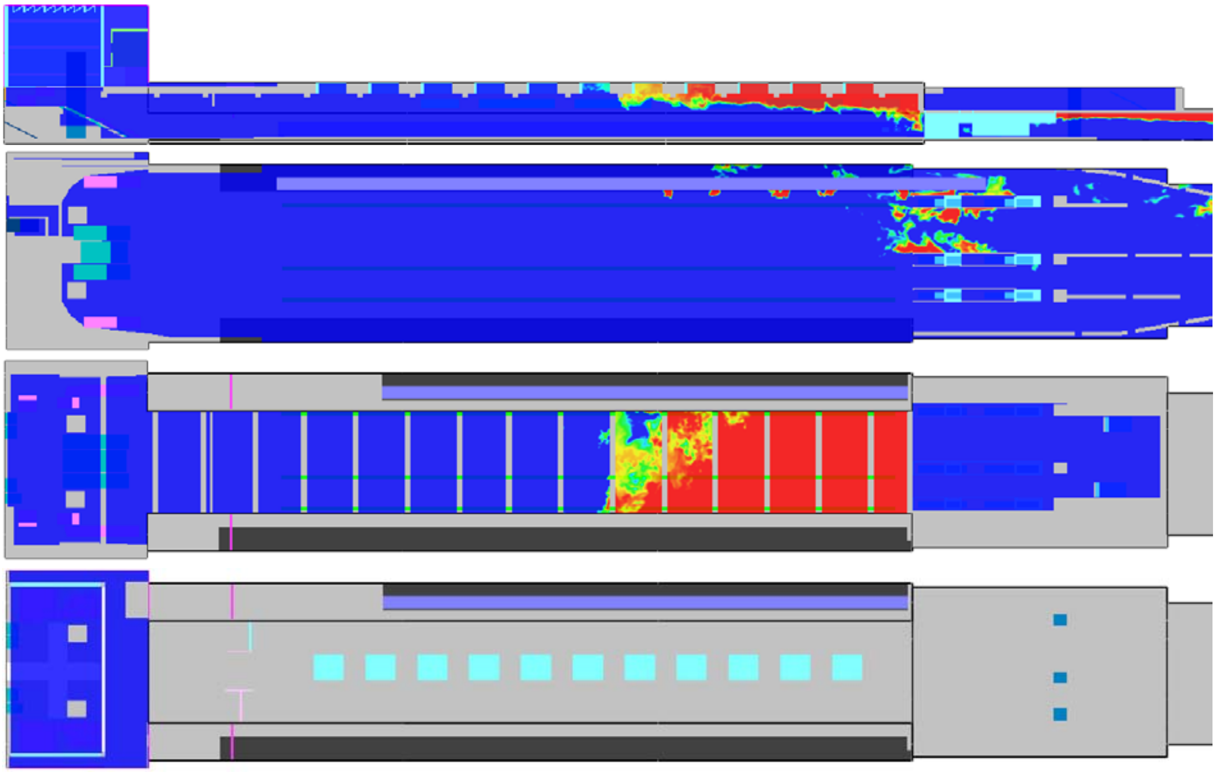


CO

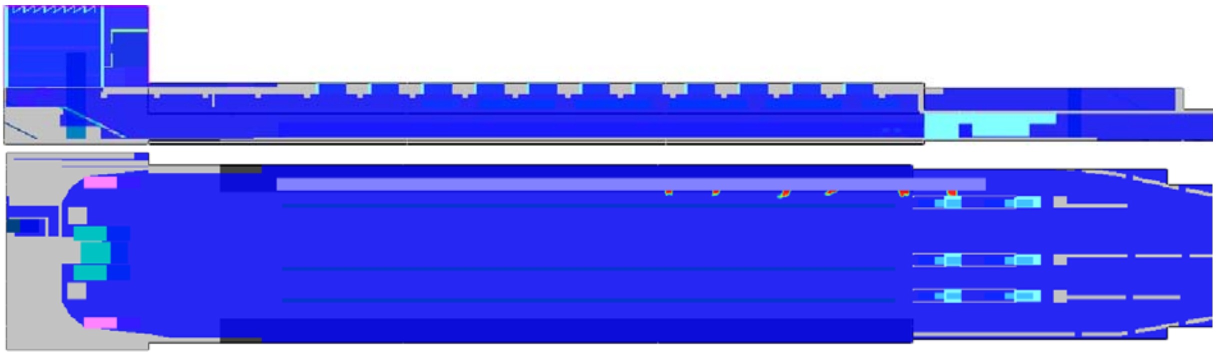


Fire Scenario 3E - Time = 720 seconds

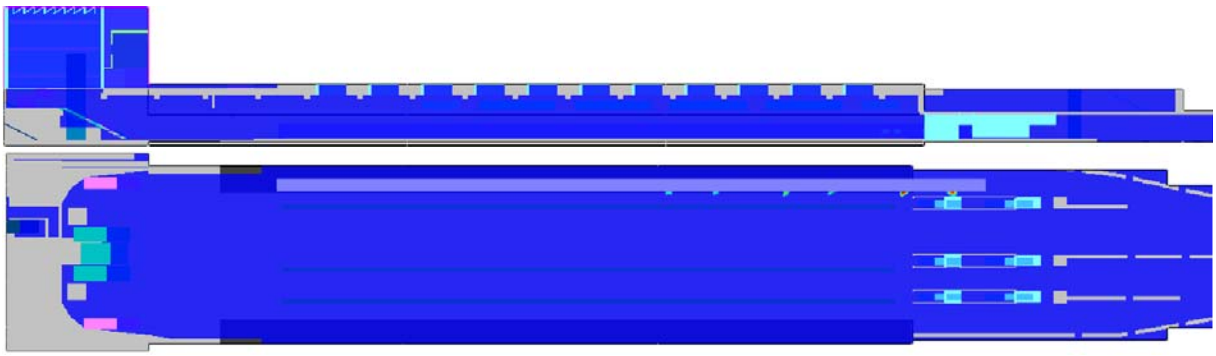
Visibility



Temperature

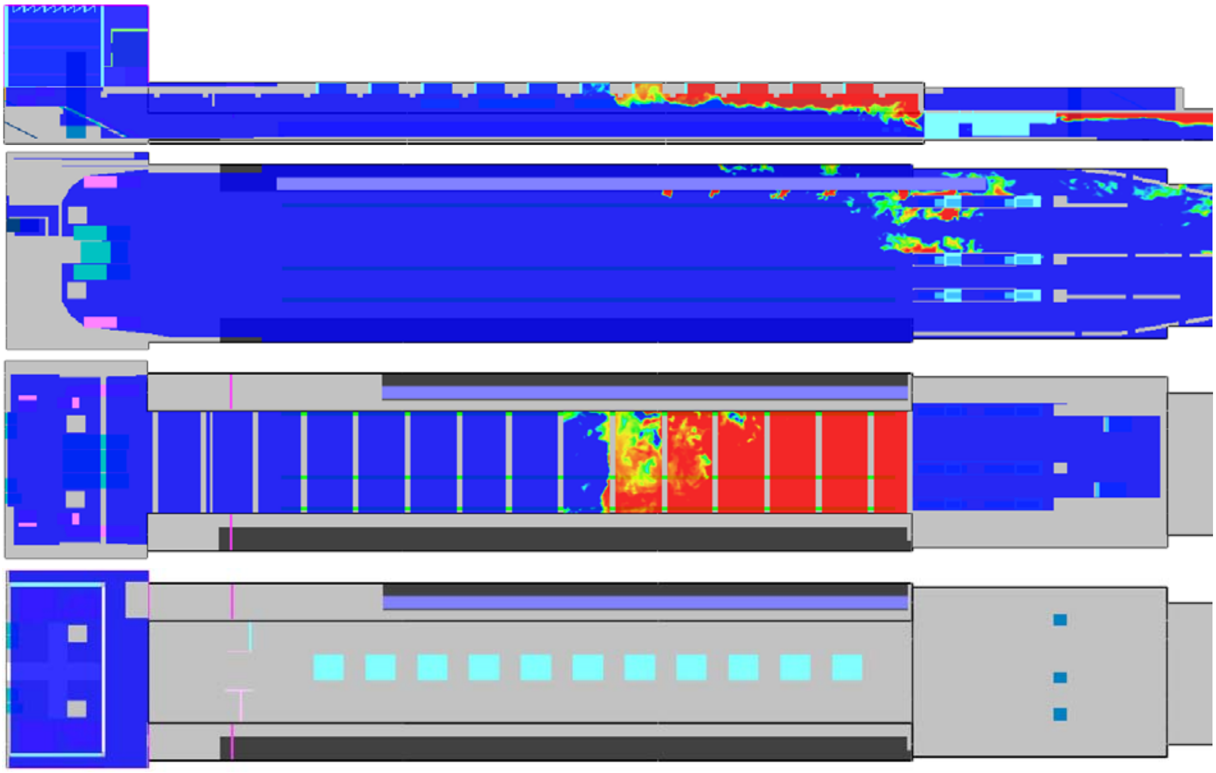


CO

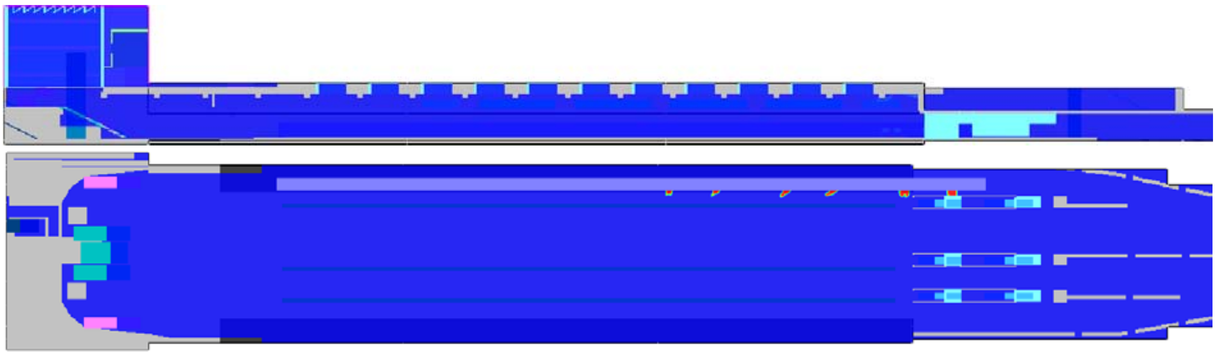


Fire Scenario 3E - Time = 840 seconds

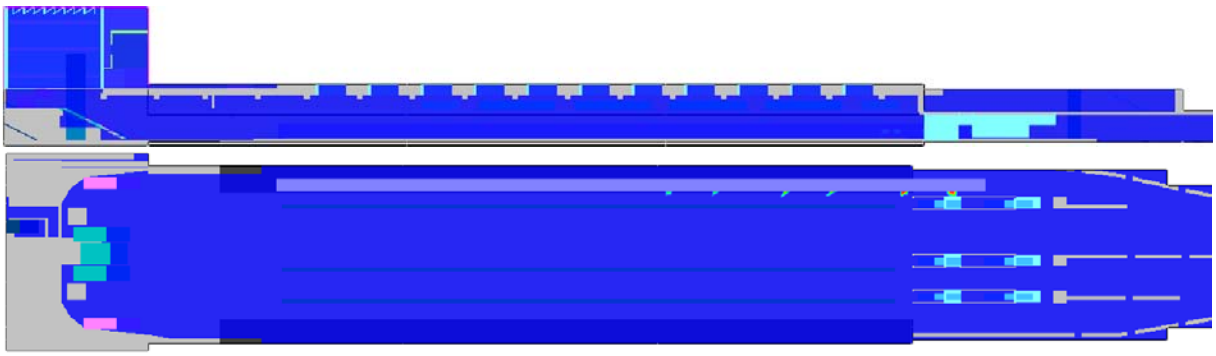
Visibility



Temperature

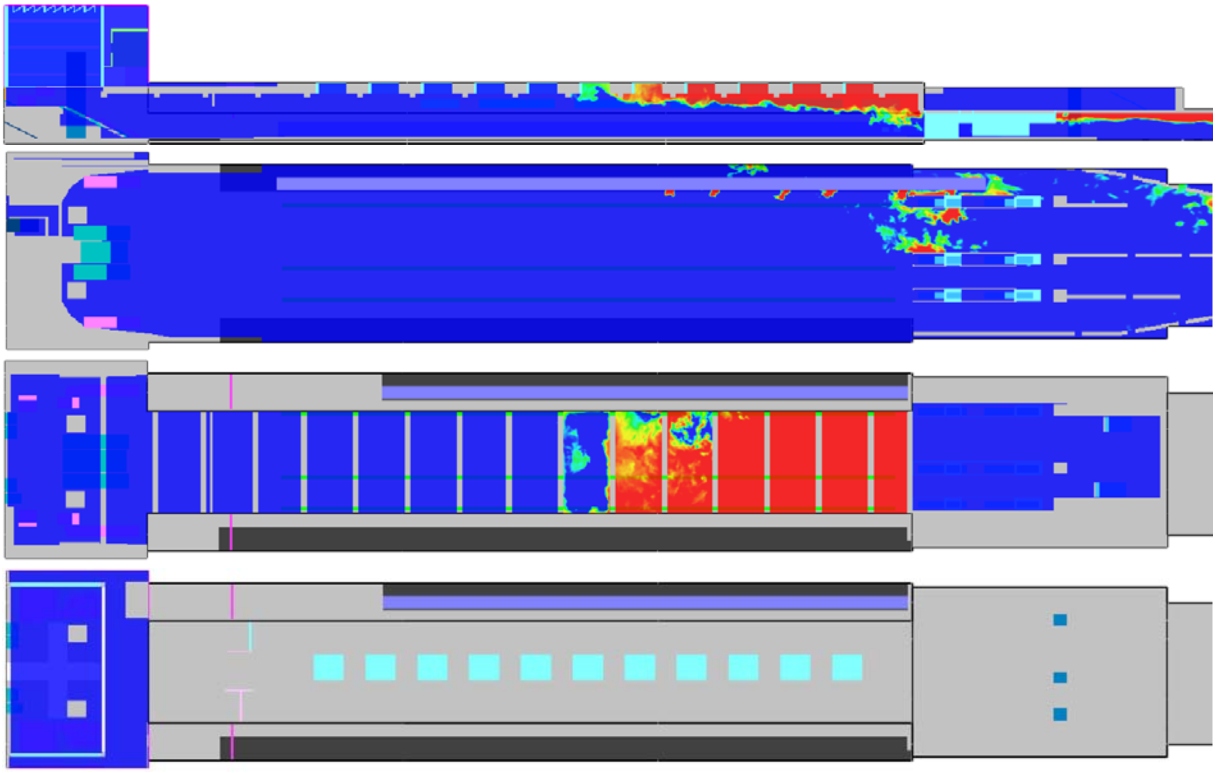


CO

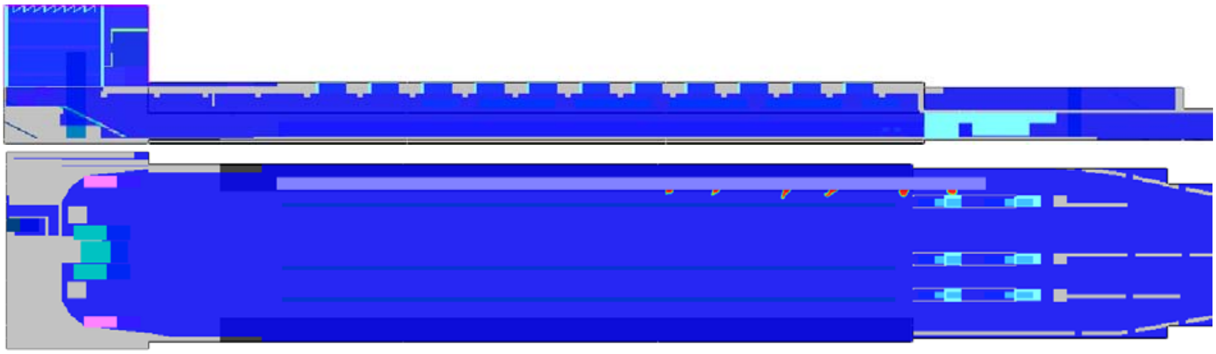


Fire Scenario 3E - Time = 960 seconds

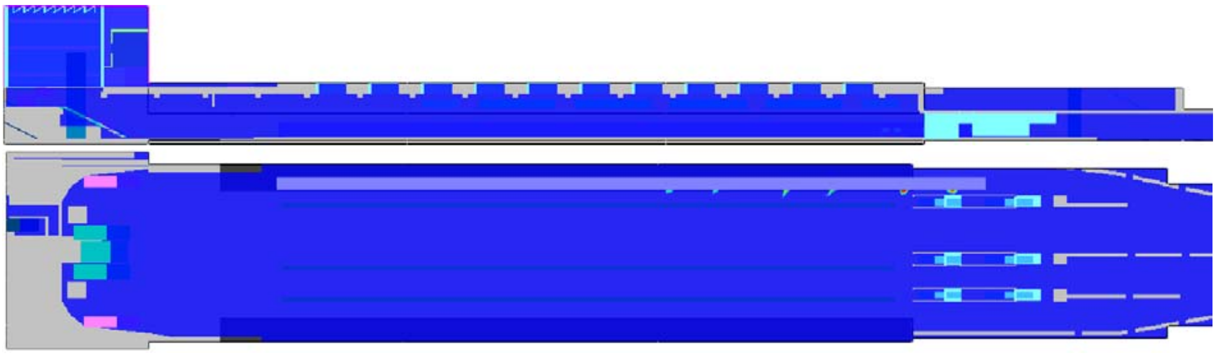
Visibility



Temperature

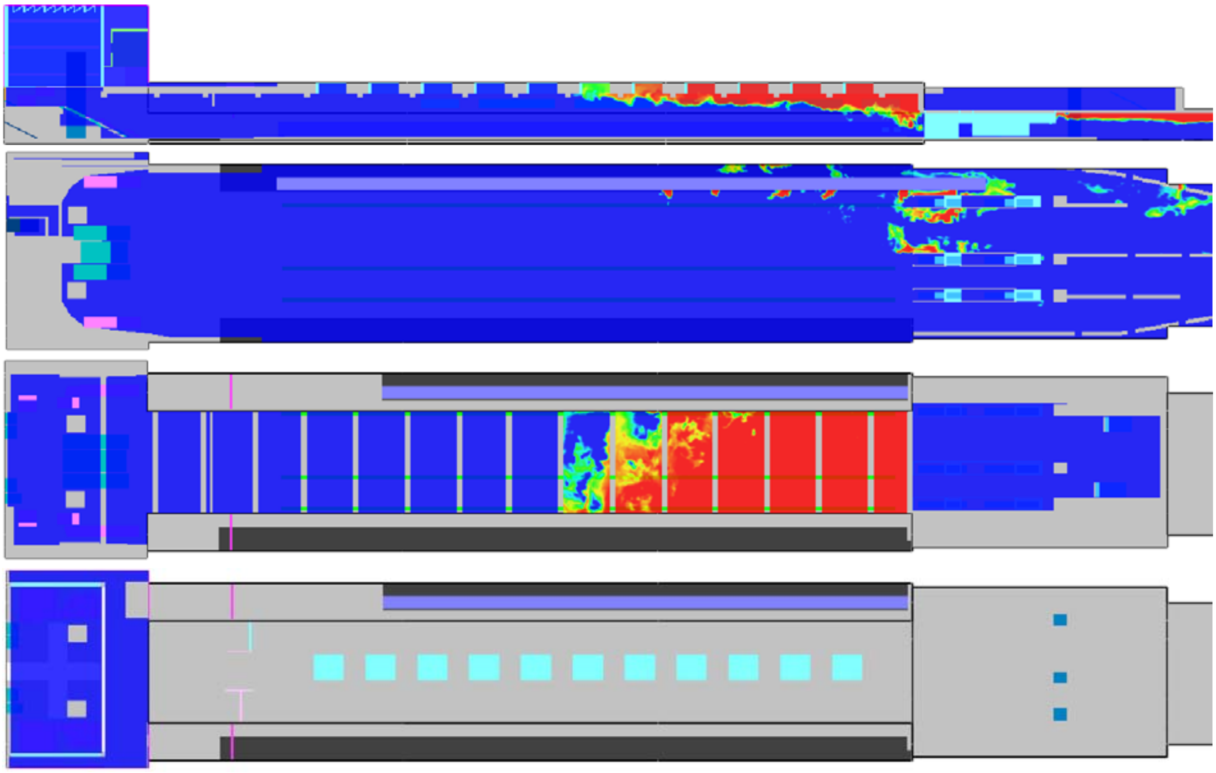


CO

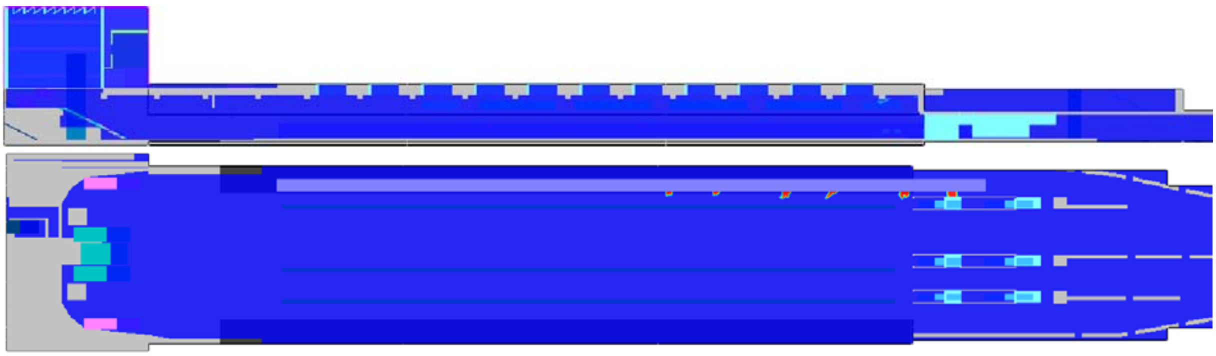


Fire Scenario 3E - Time = 1,110 seconds

Visibility



Temperature



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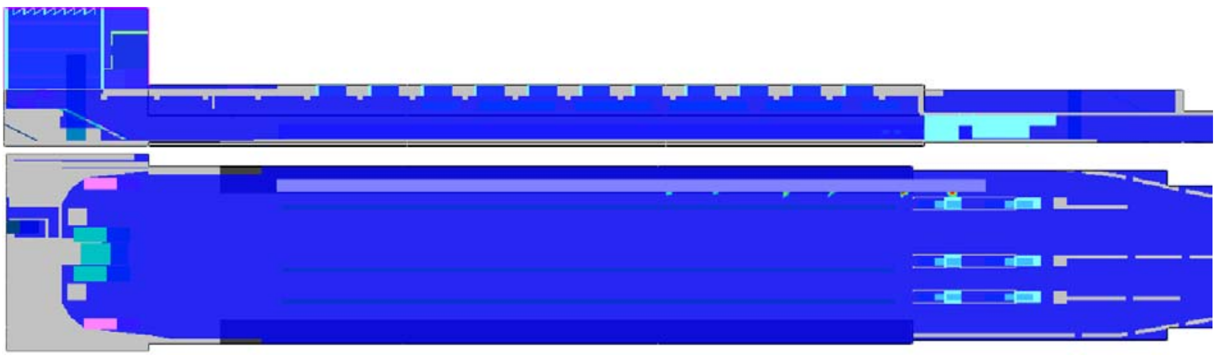
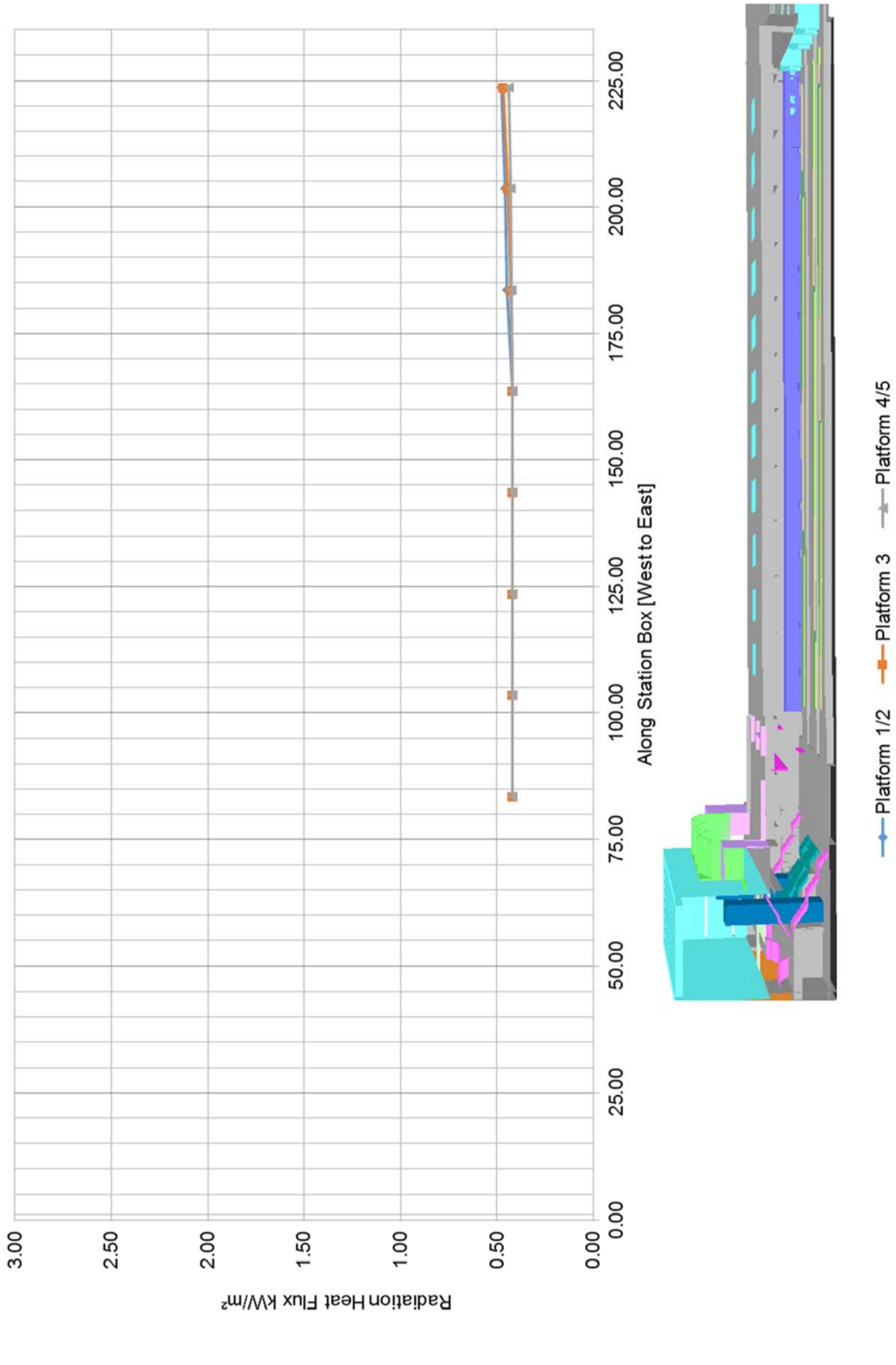
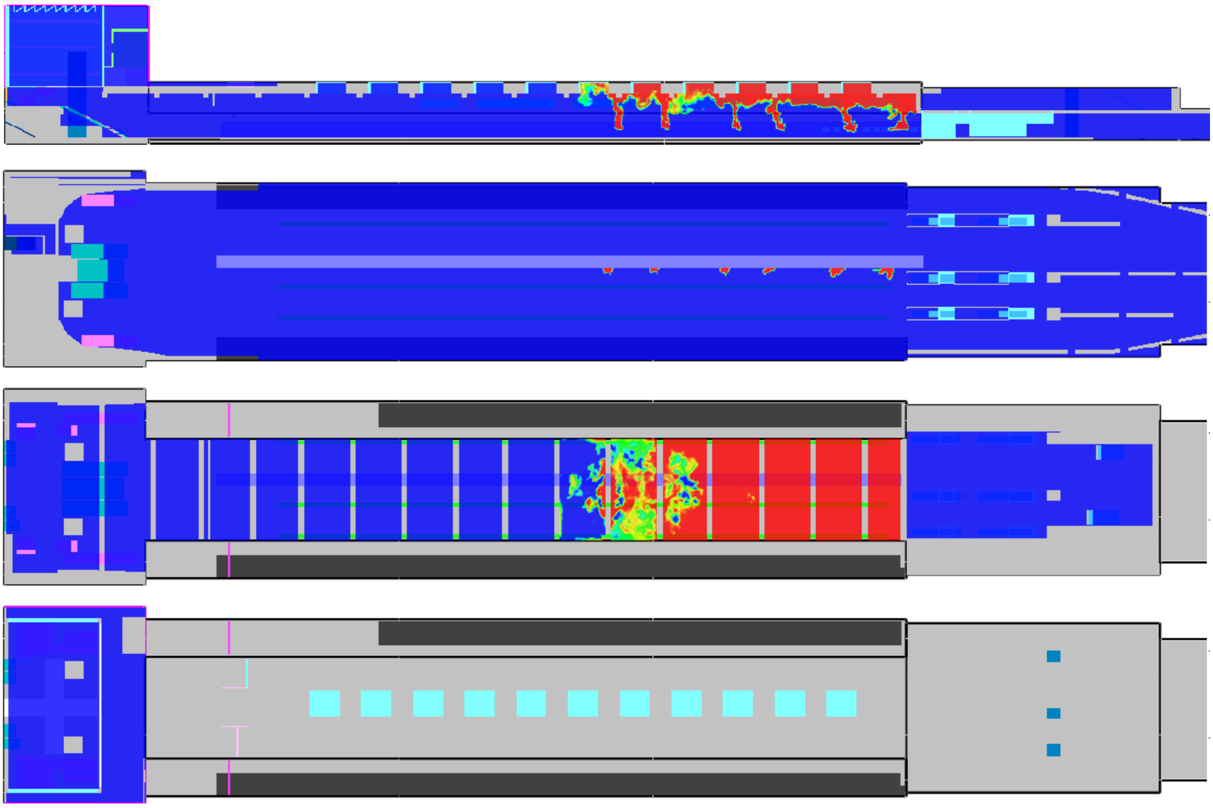




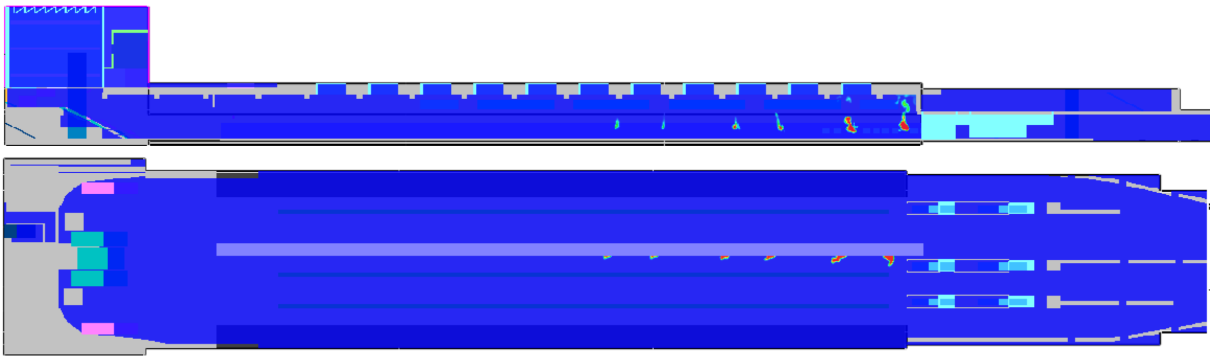
Radiation Heat Flux kW/m²
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
Along Station Box [West to East]
Platform 1/2
Platform 3
Platform 4/5

Fire Scenario 4E - Time = 120 seconds

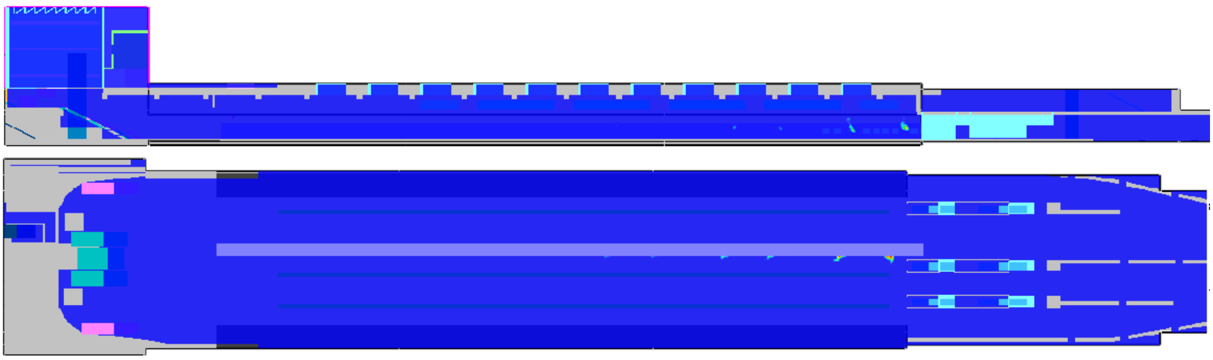
Visibility



Temperature

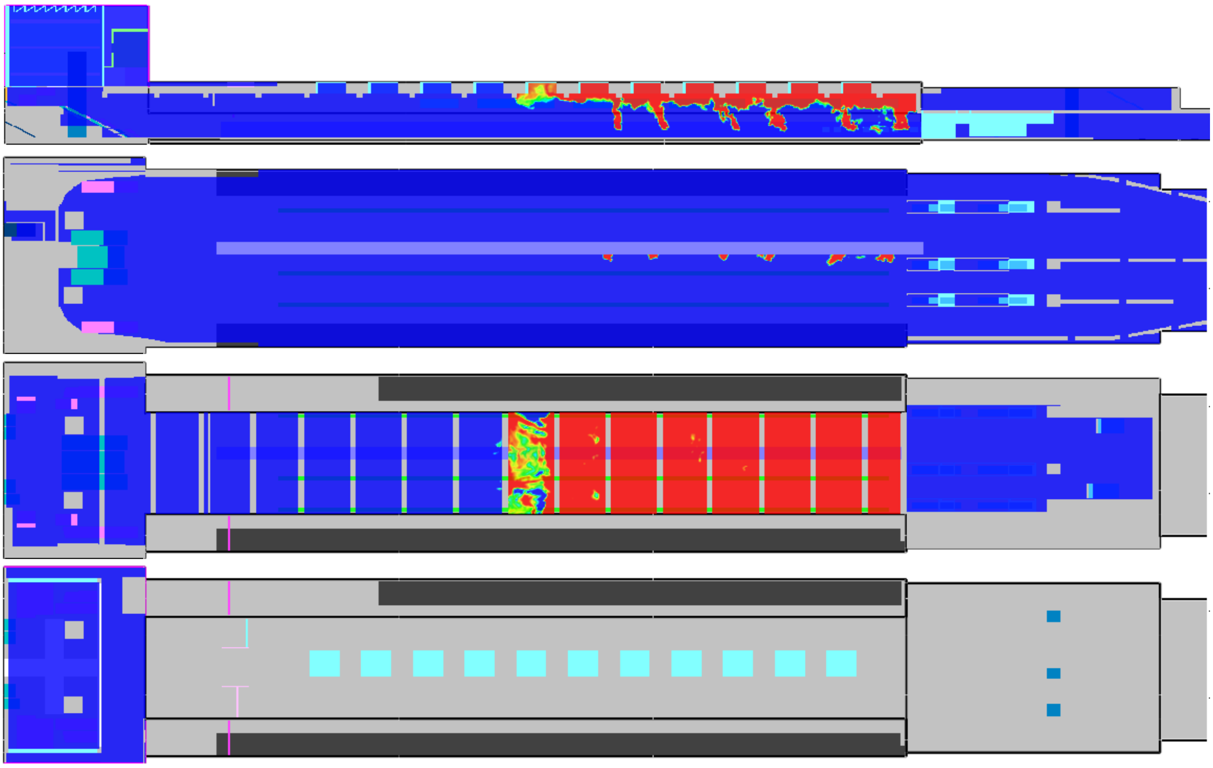


CO

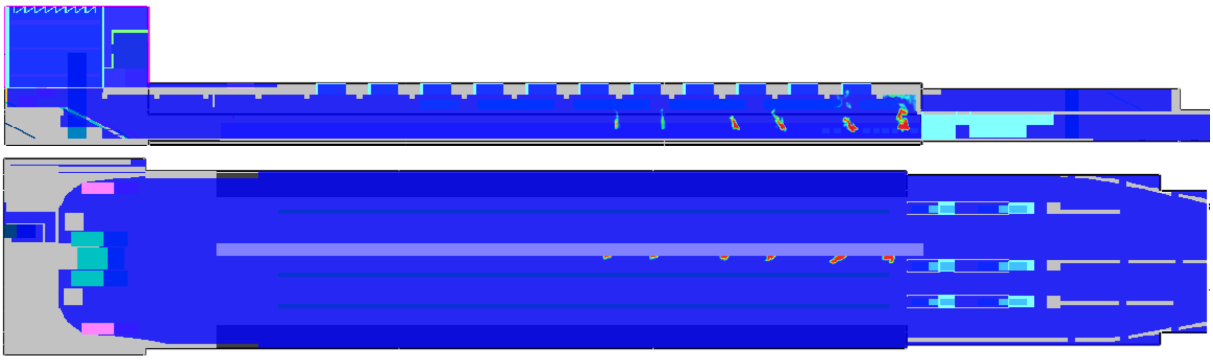


Fire Scenario 4E - Time = 240 seconds

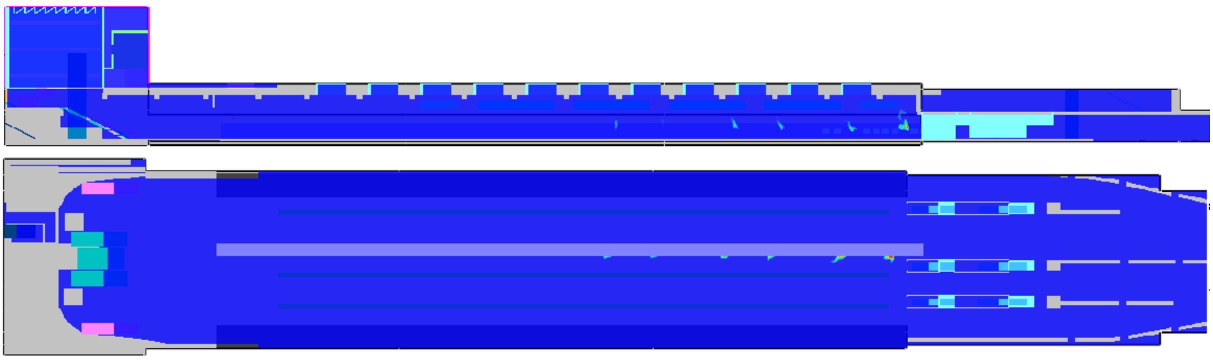
Visibility



Temperature

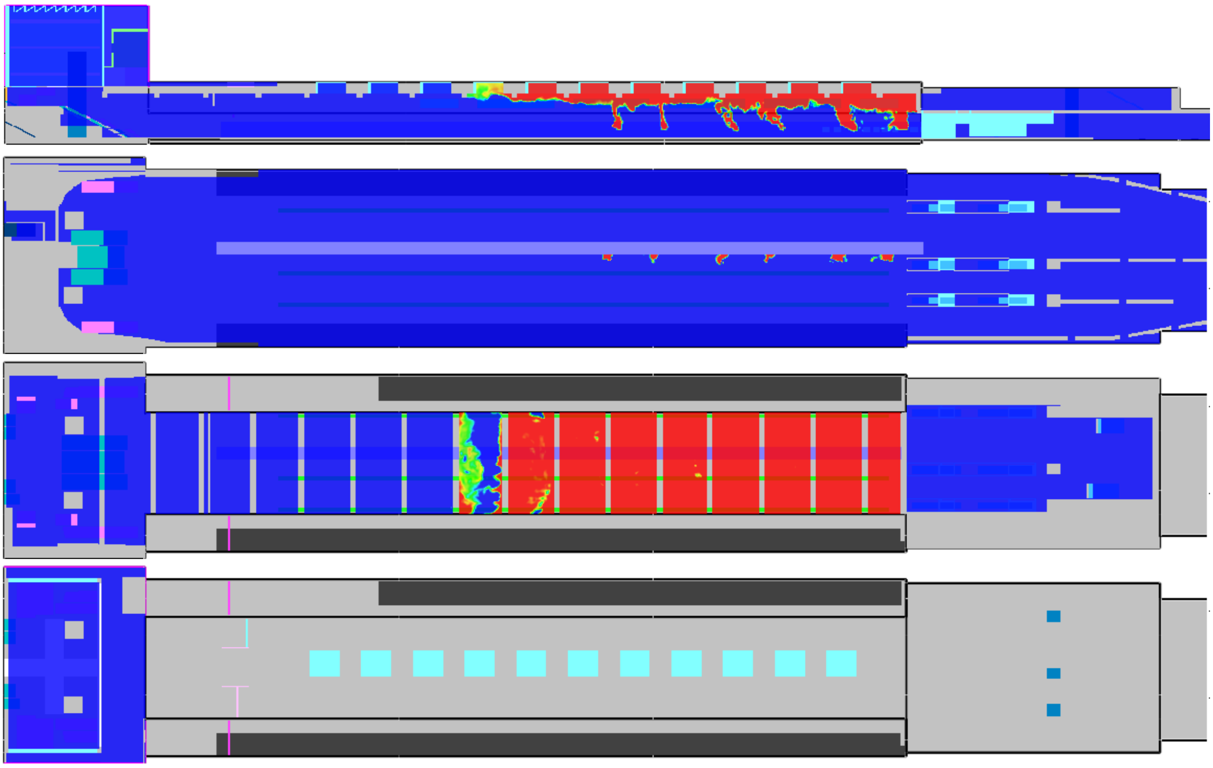


CO

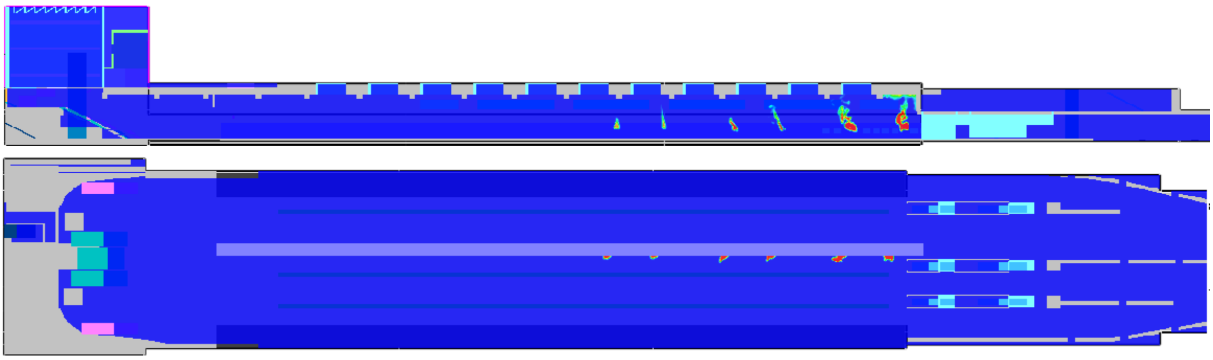


Fire Scenario 4E - Time = 360 seconds

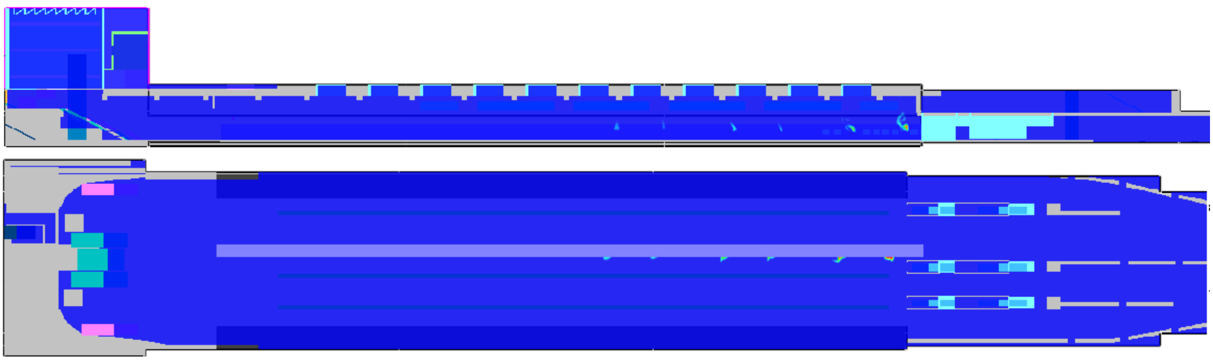
Visibility



Temperature

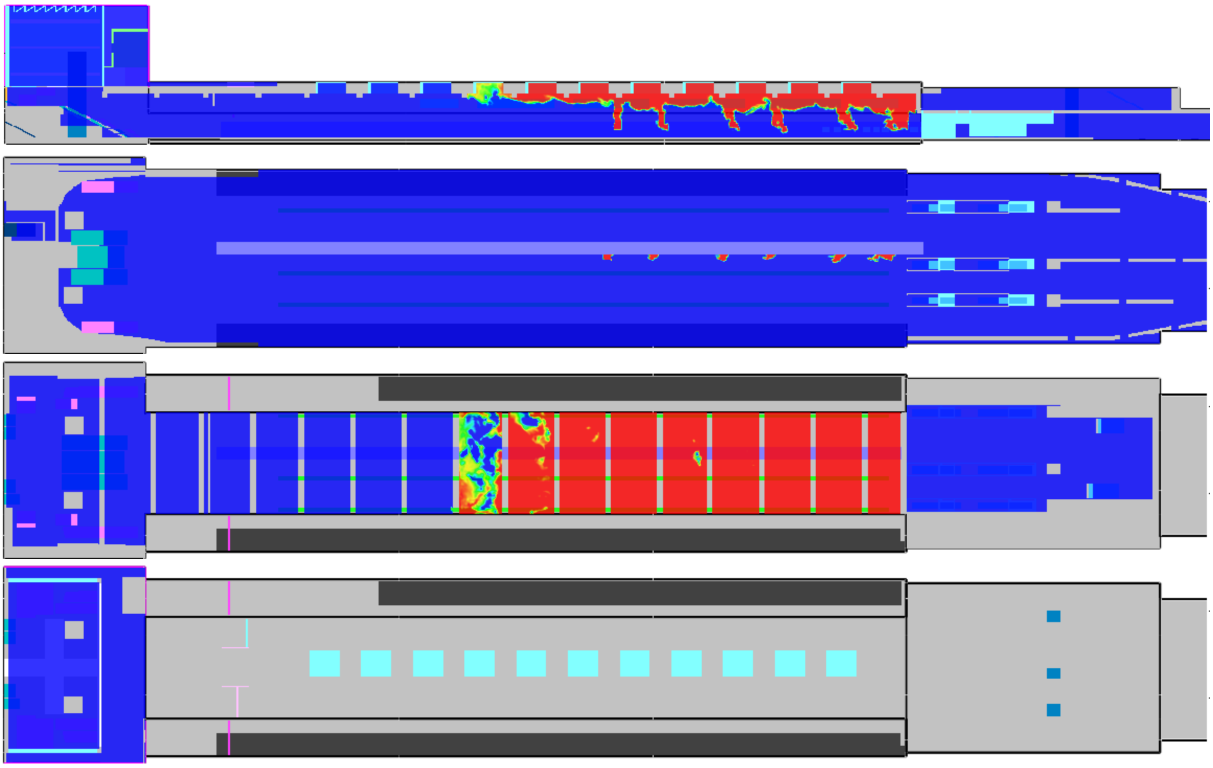


CO

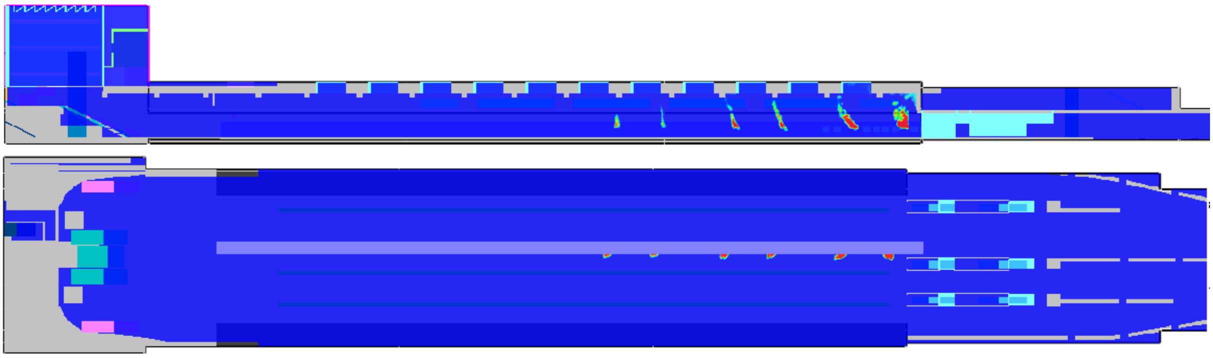


Fire Scenario 4E - Time = 480 seconds

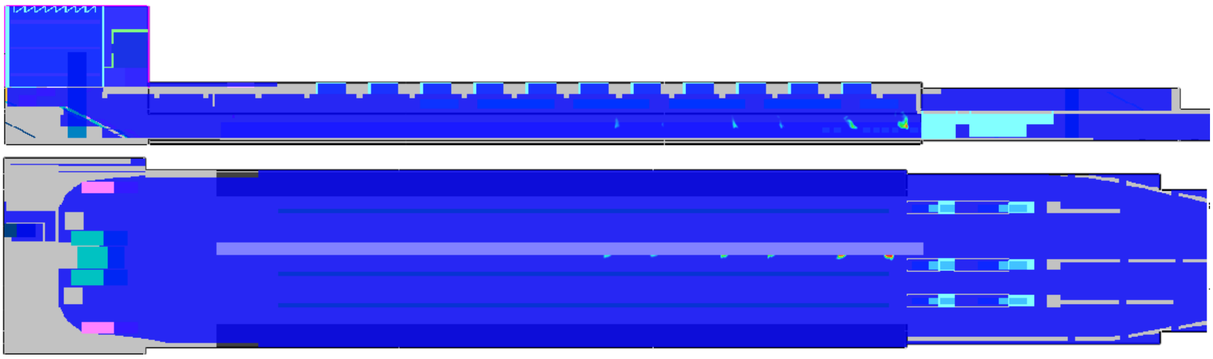
Visibility



Temperature

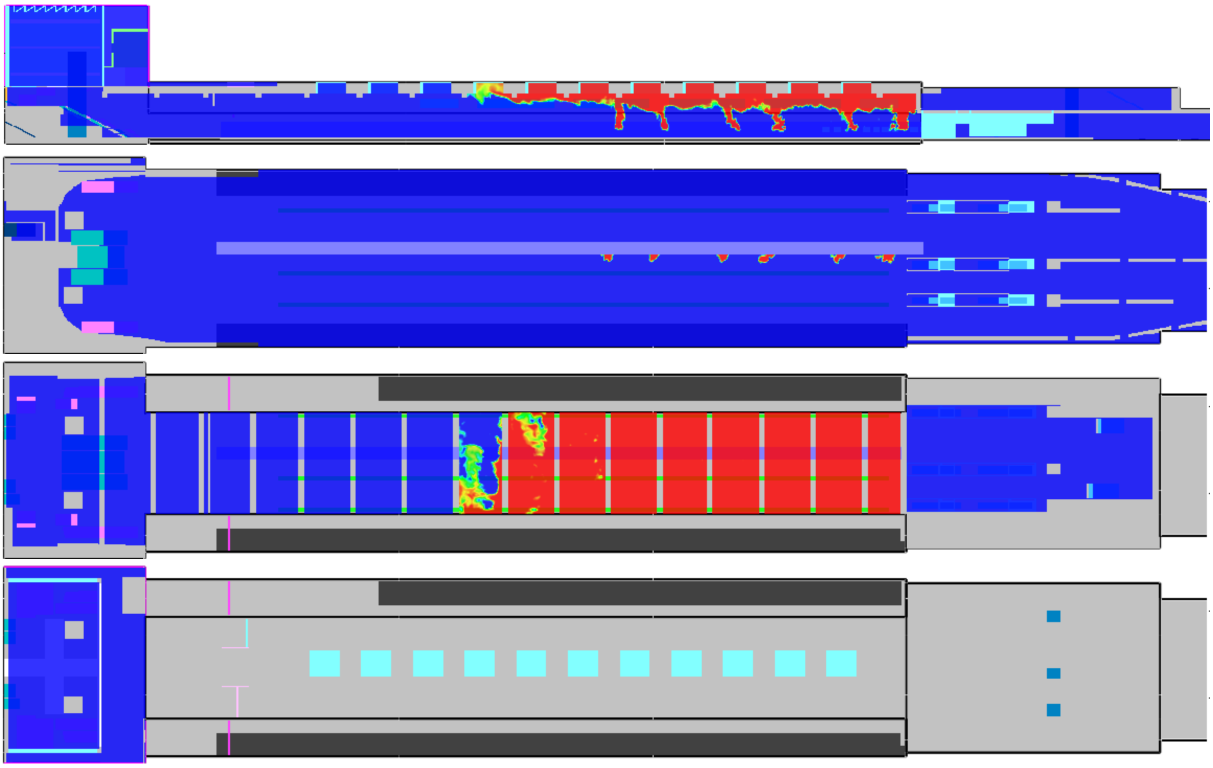


CO

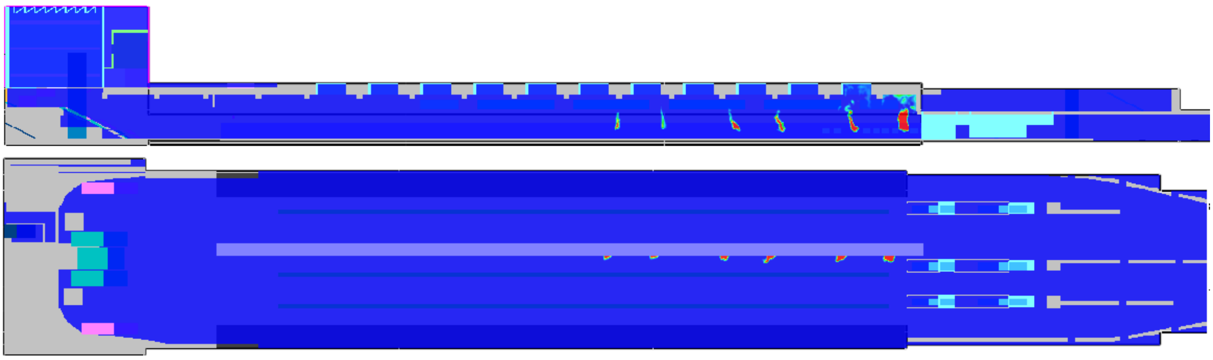


Fire Scenario 4E - Time = 600 seconds

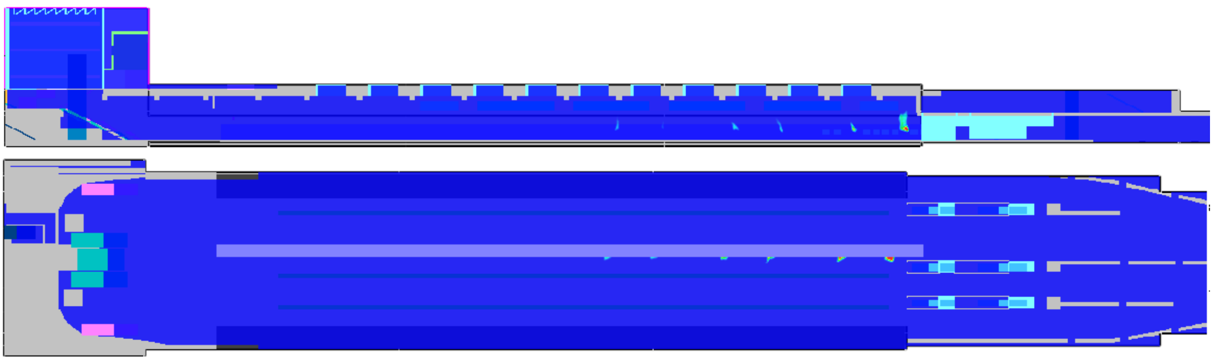
Visibility



Temperature

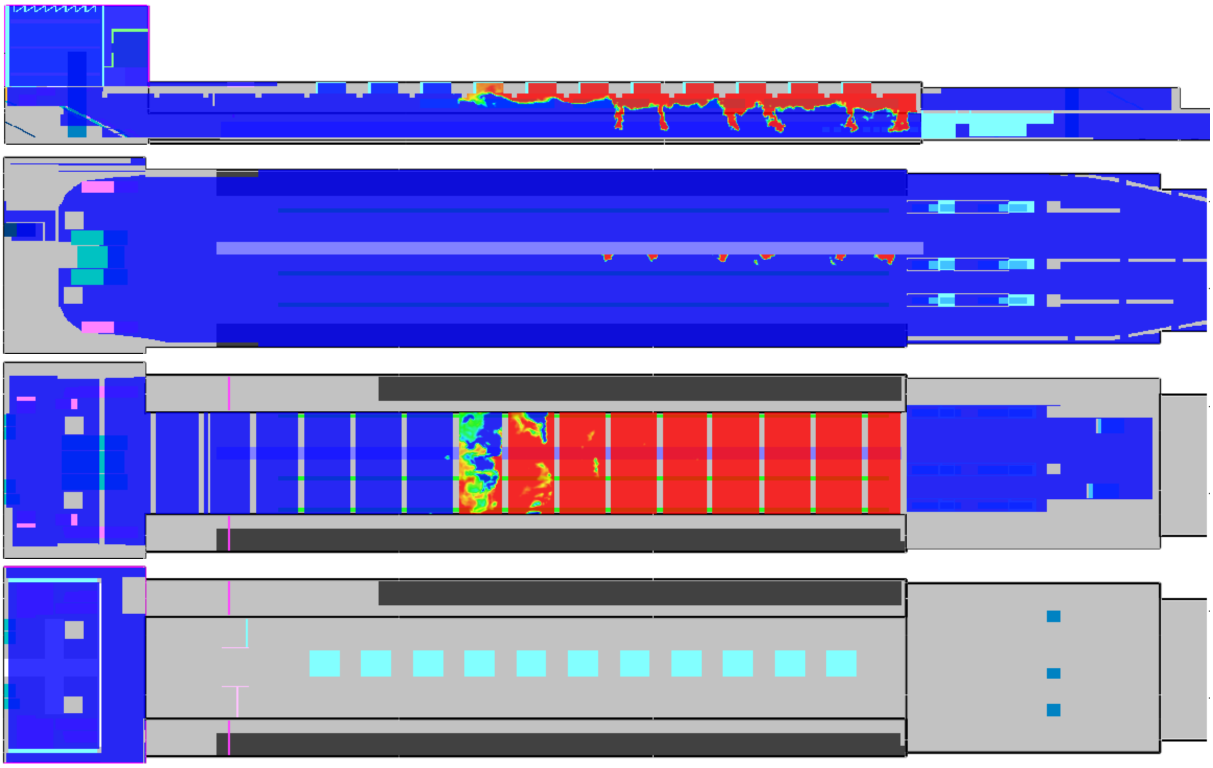


CO

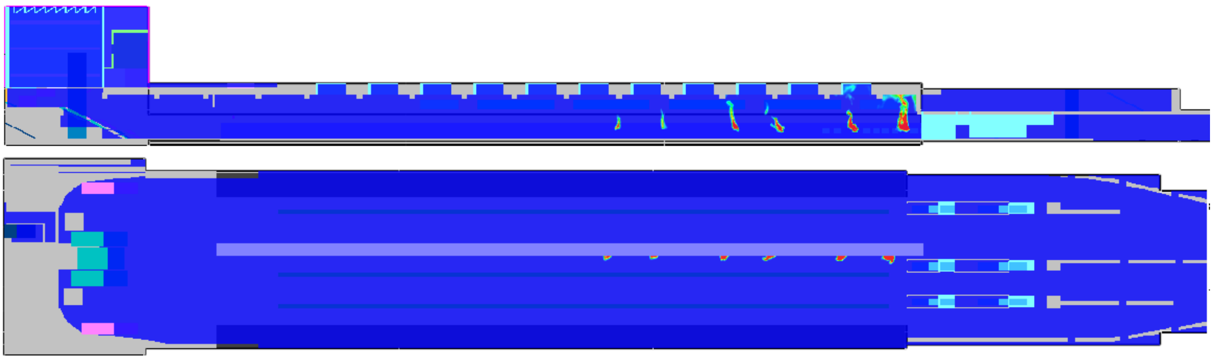


Fire Scenario 4E - Time = 720 seconds

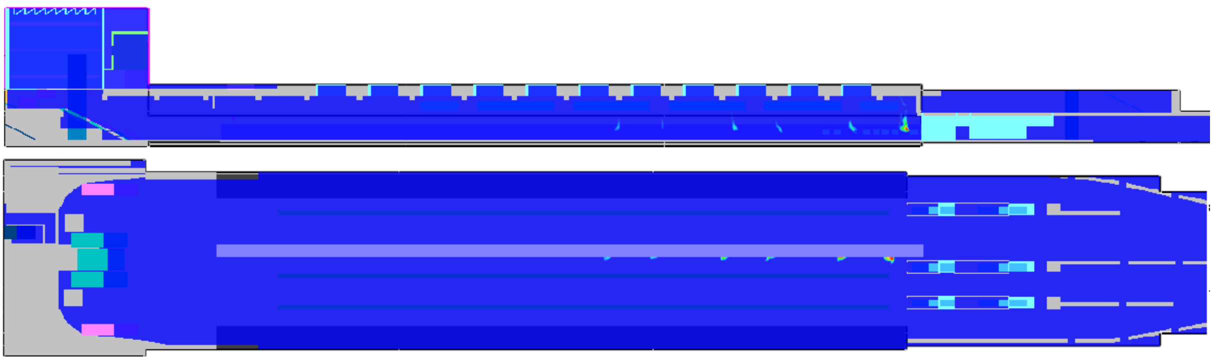
Visibility



Temperature

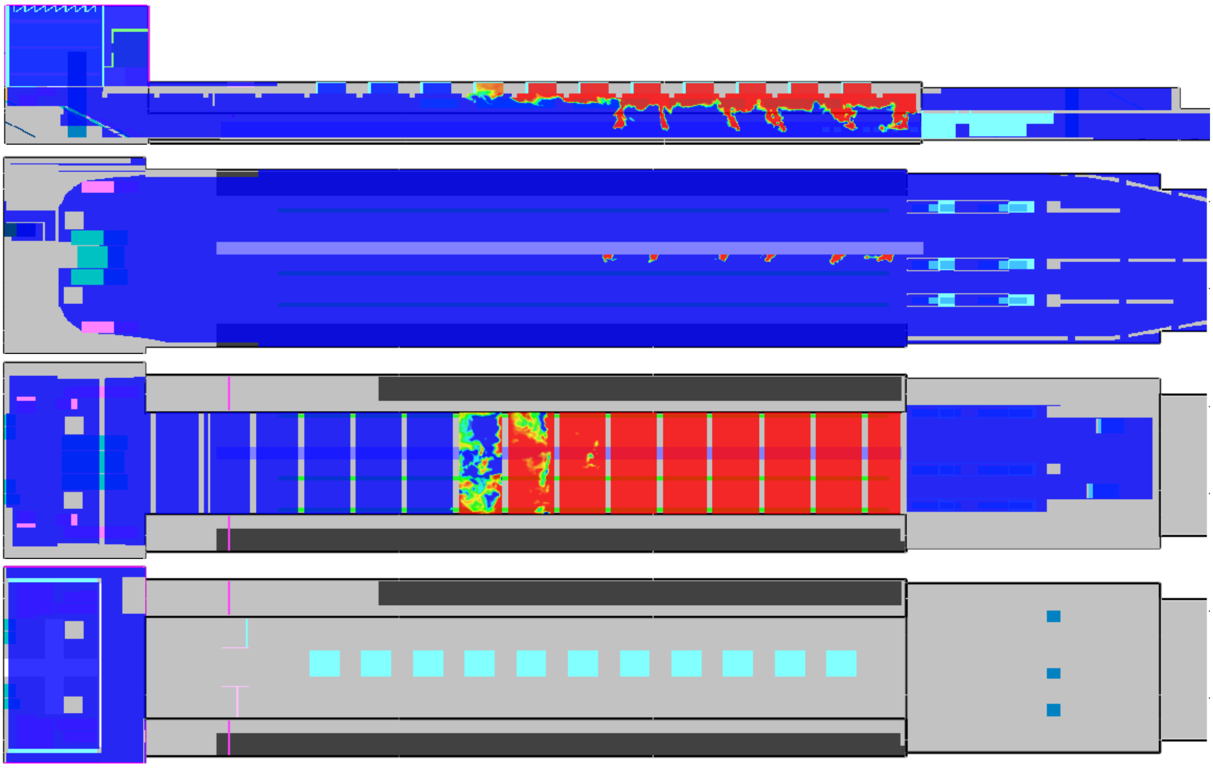


CO

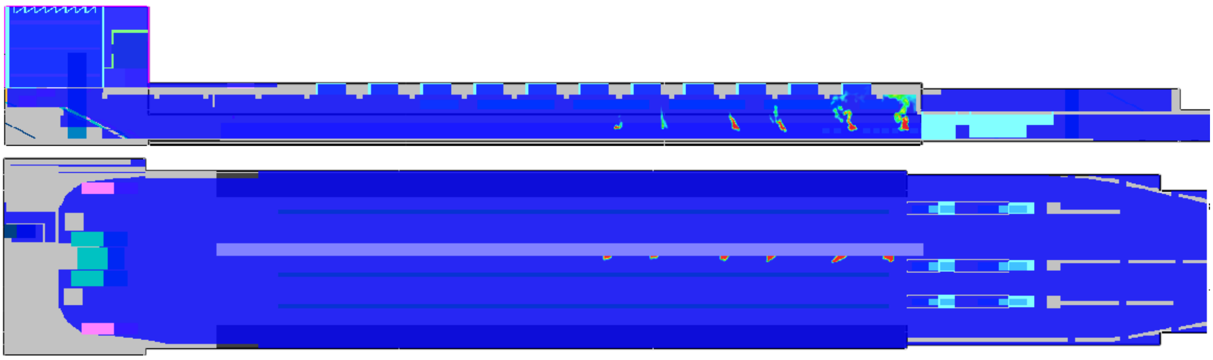


Fire Scenario 4E - Time = 840 seconds

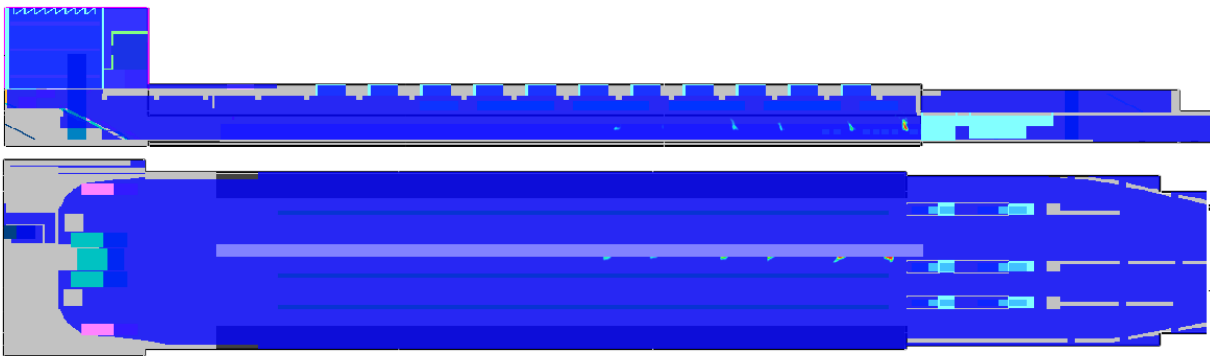
Visibility



Temperature

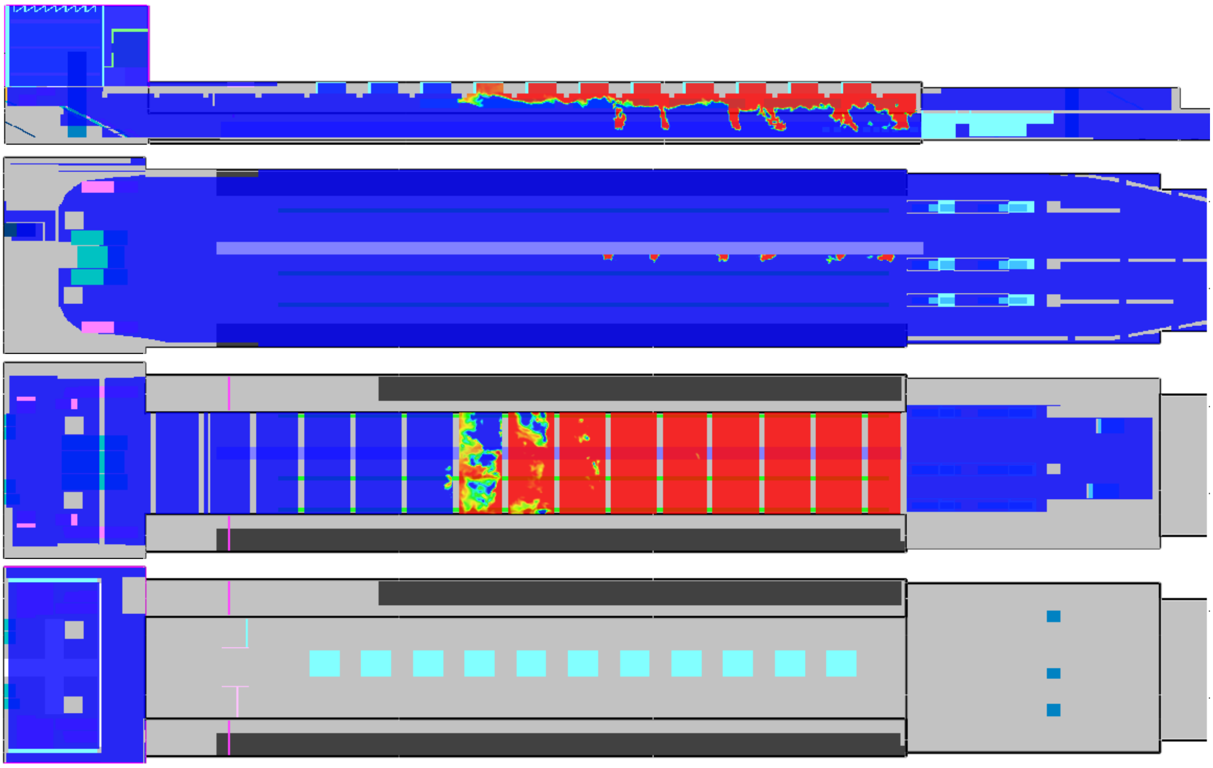


CO

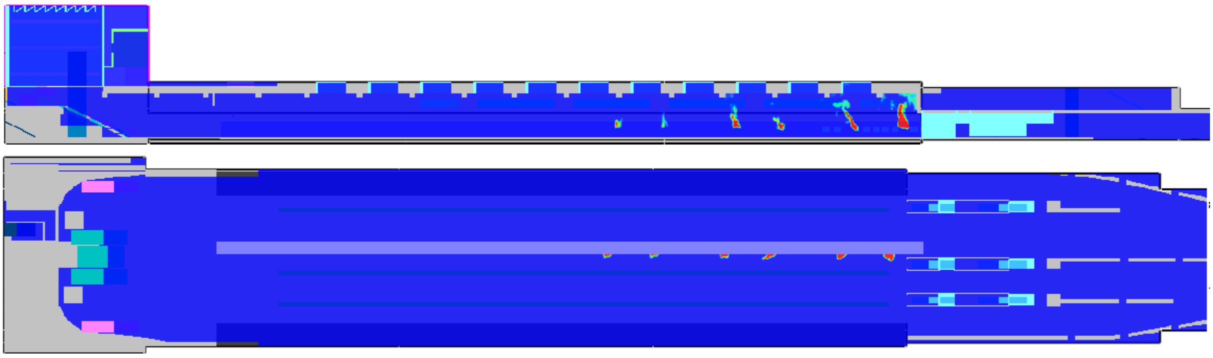


Fire Scenario 4E - Time = 960 seconds

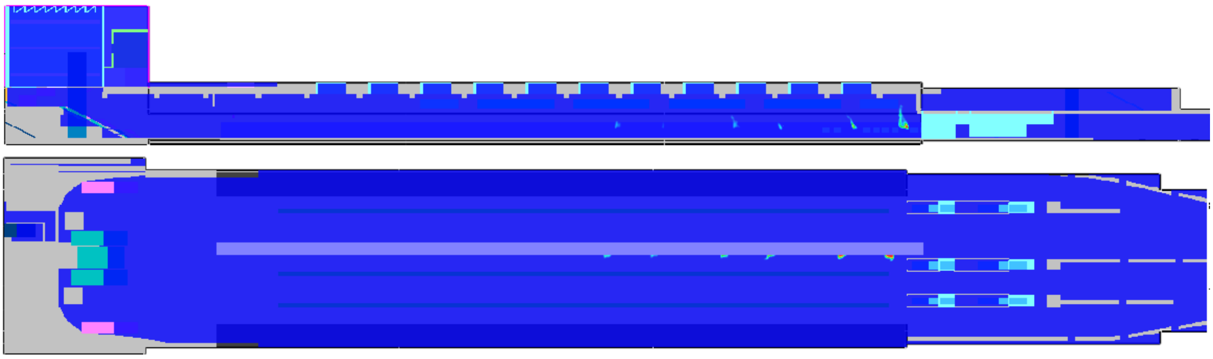
Visibility



Temperature

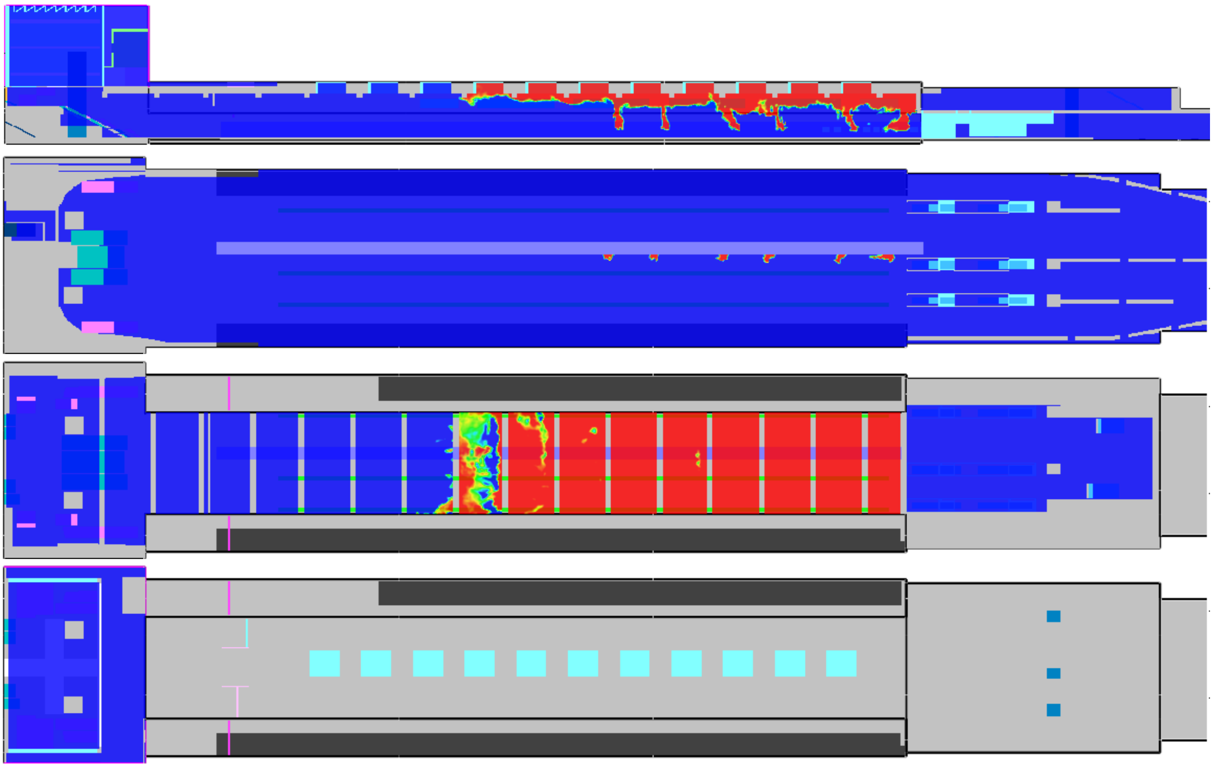


CO

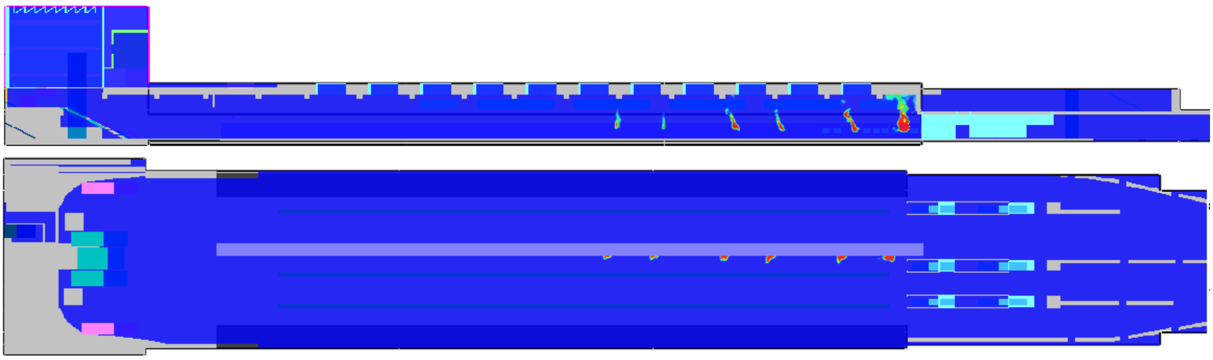


Fire Scenario 4E - Time = 1,200 seconds

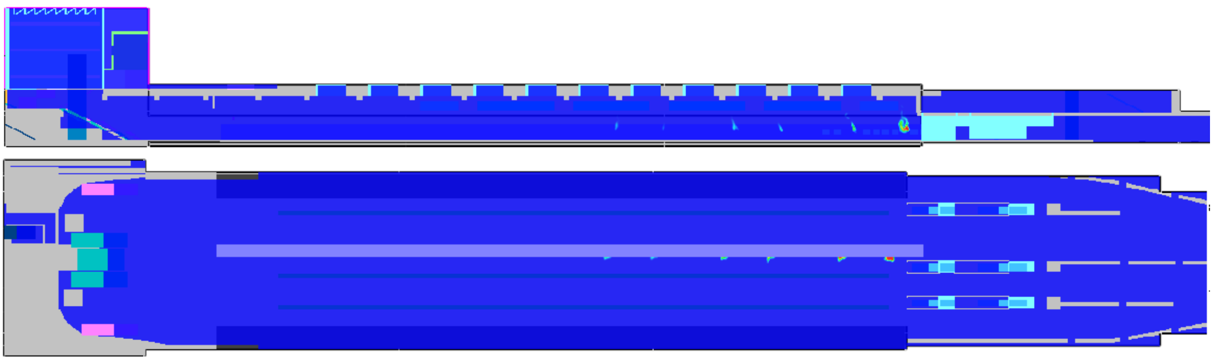
Visibility

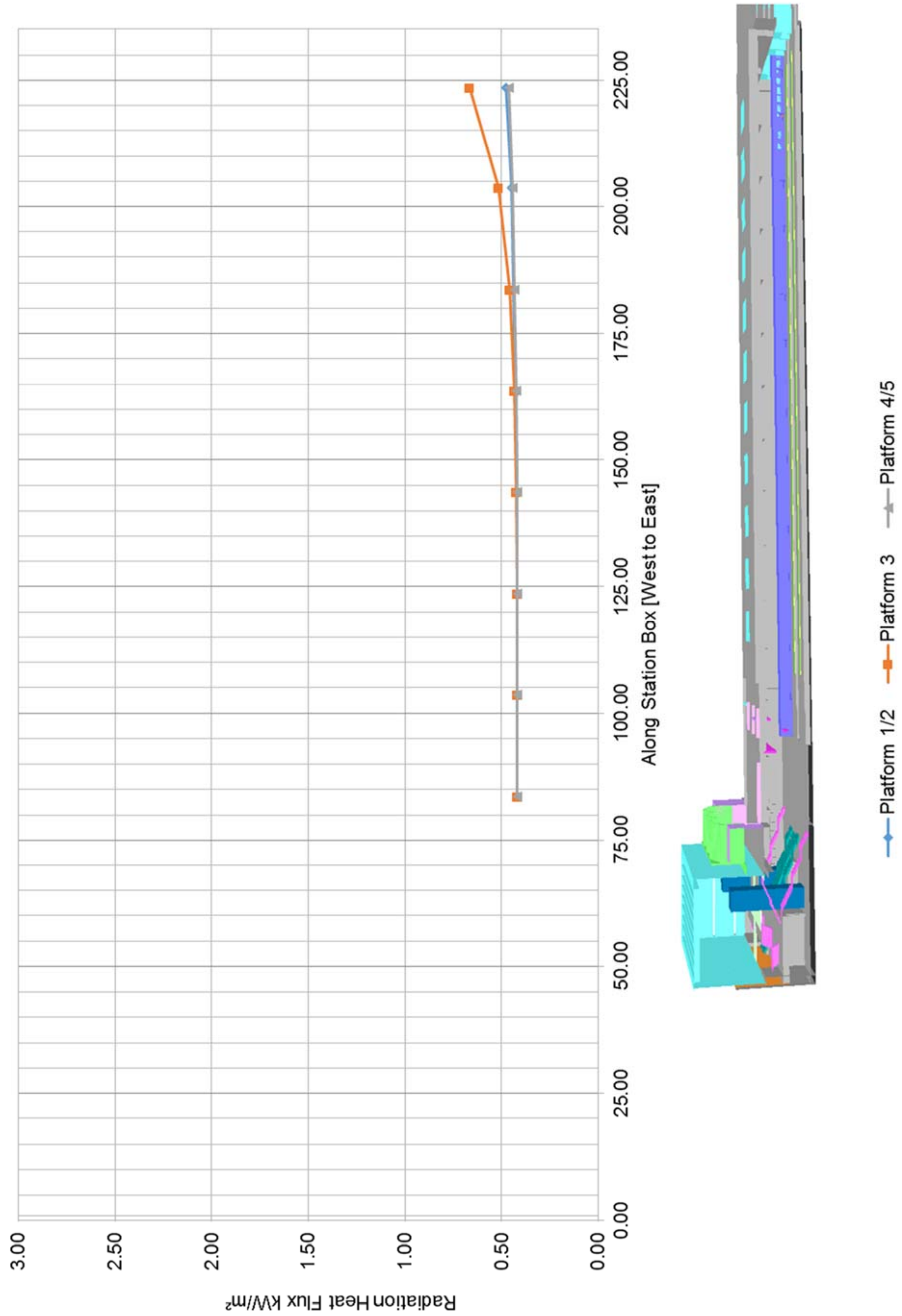


Temperature



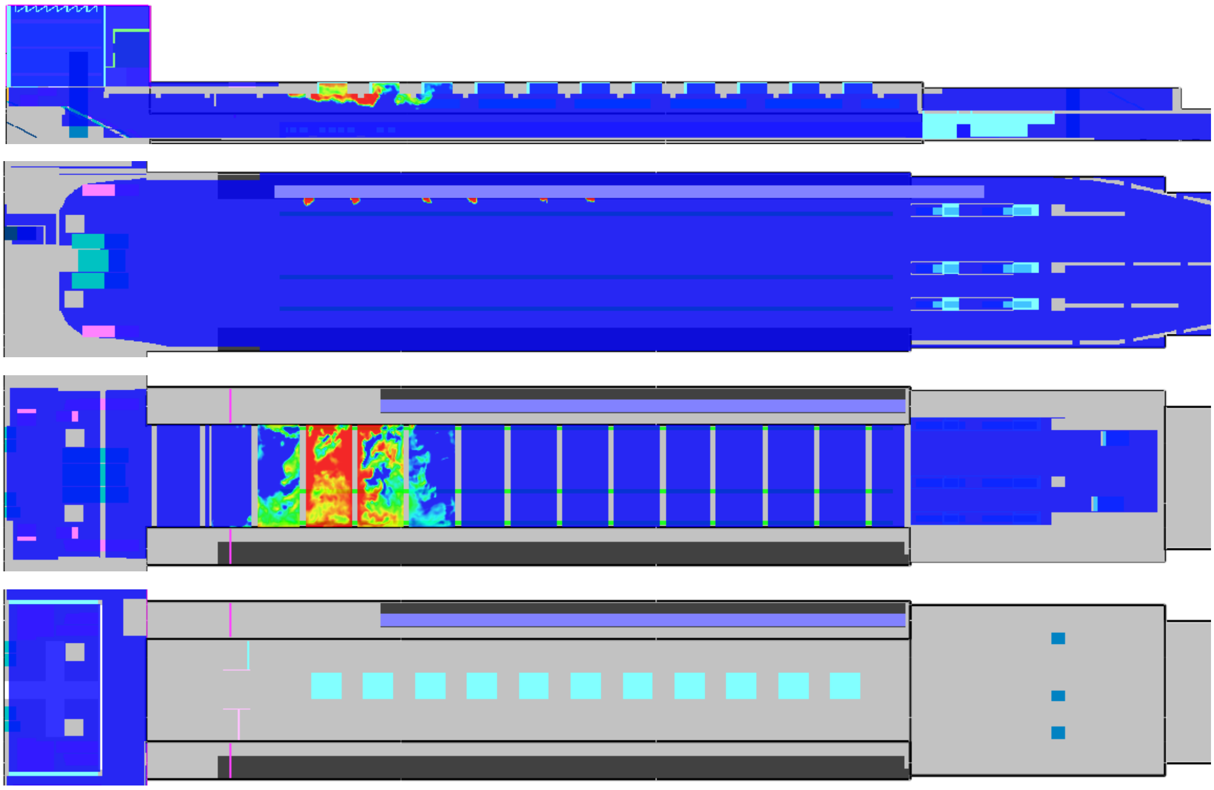
CO



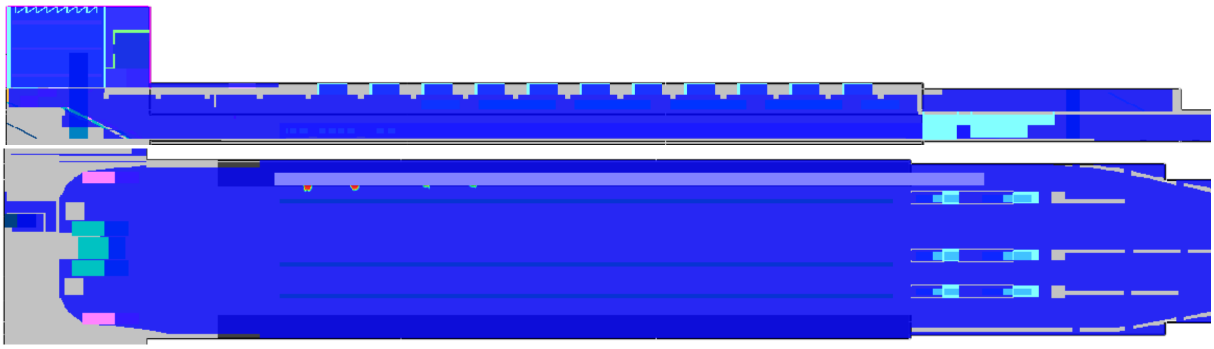

Radiation Heat Flux kW/m²
Along Station Box [West to East]
0.00
0.50
1.00
1.50
2.00
2.50
3.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
Platform 1/2
Platform 3
Platform 4/5

Fire Scenario 5E - Time = 120 seconds

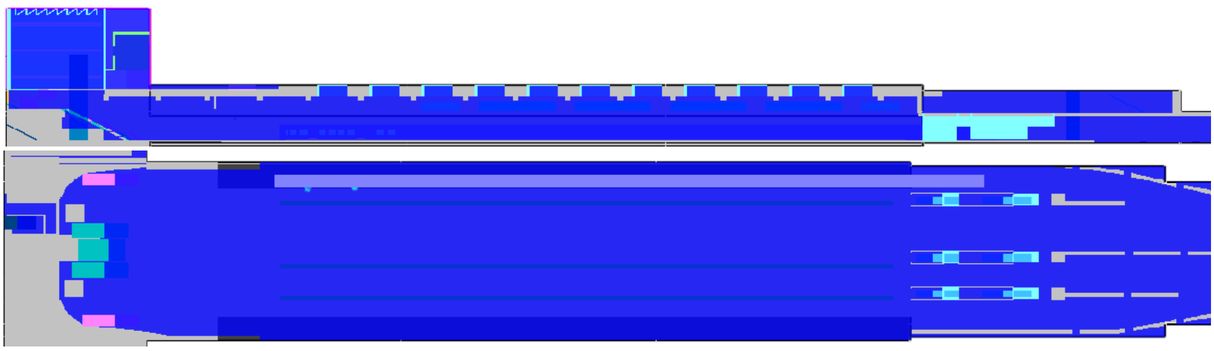
Visibility



Temperature

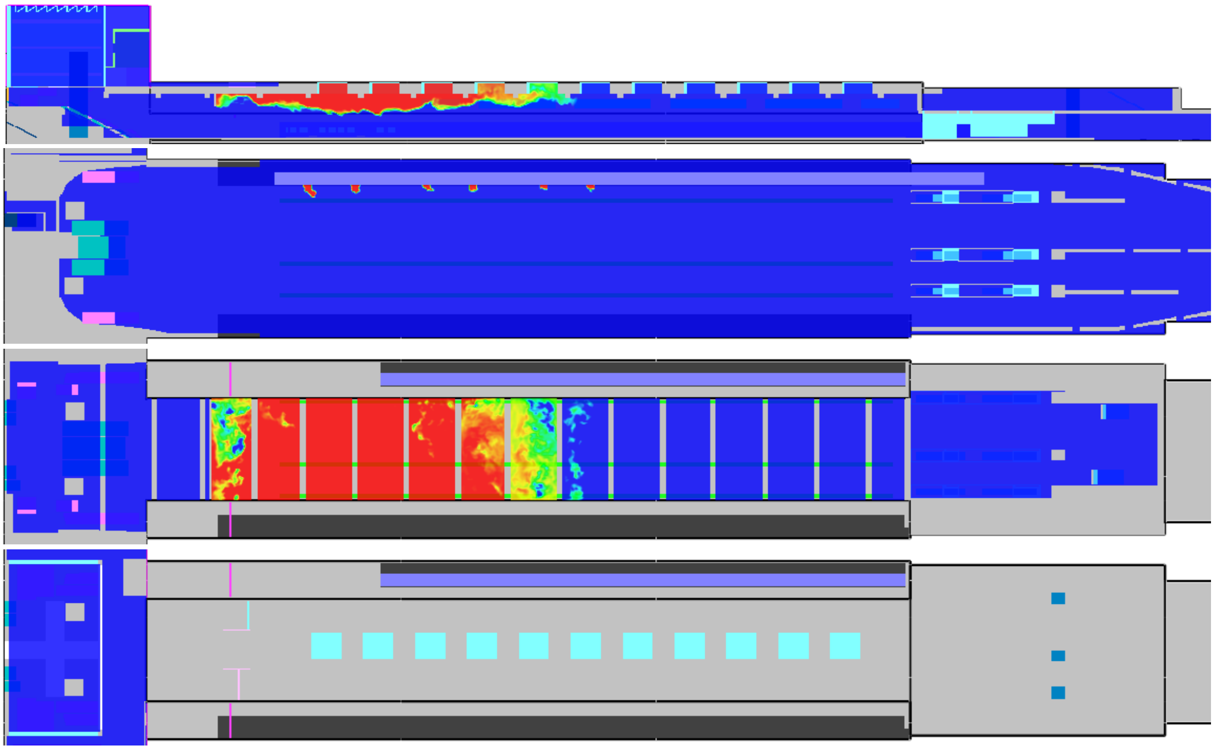


CO

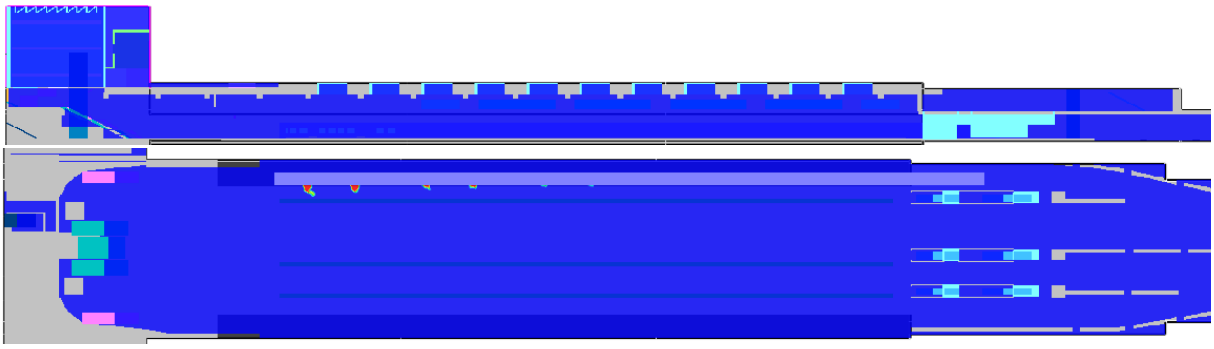


Fire Scenario 5E - Time = 240 seconds

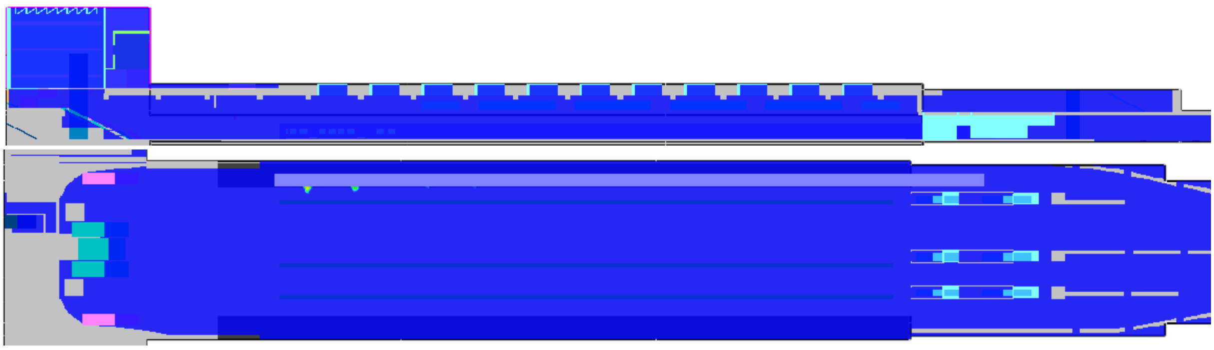
Visibility



Temperature

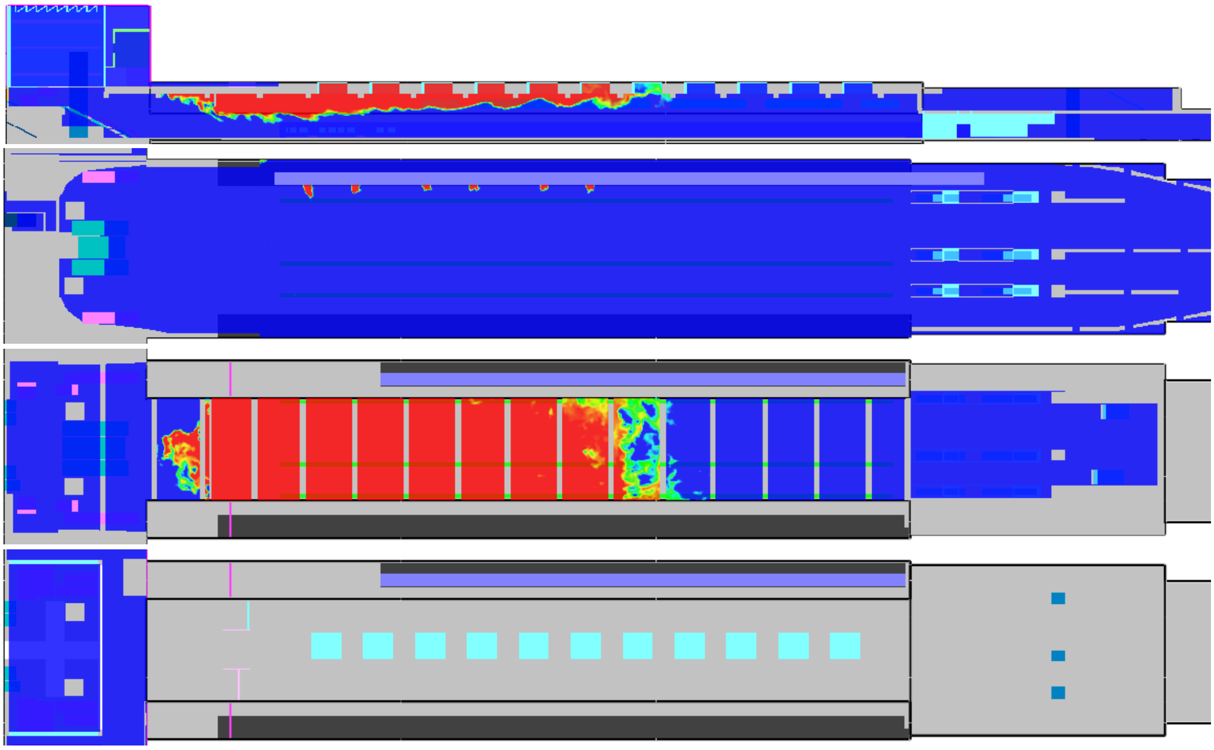


CO

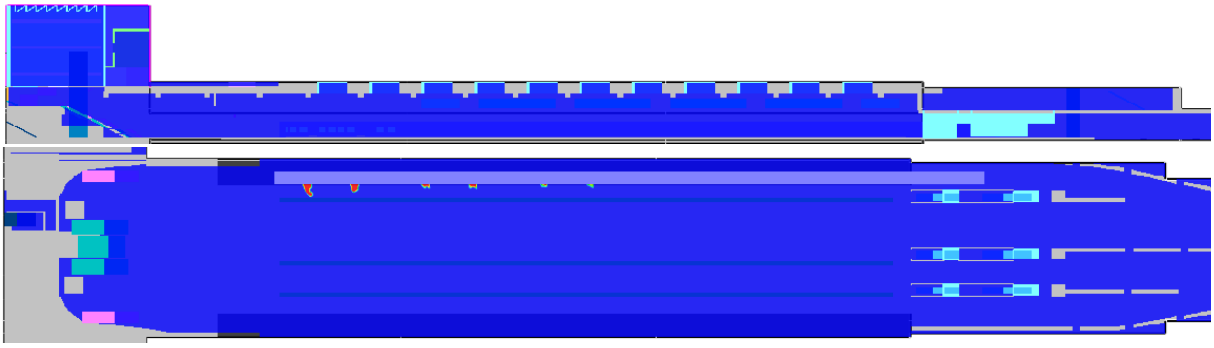


Fire Scenario 5E - Time = 360 seconds

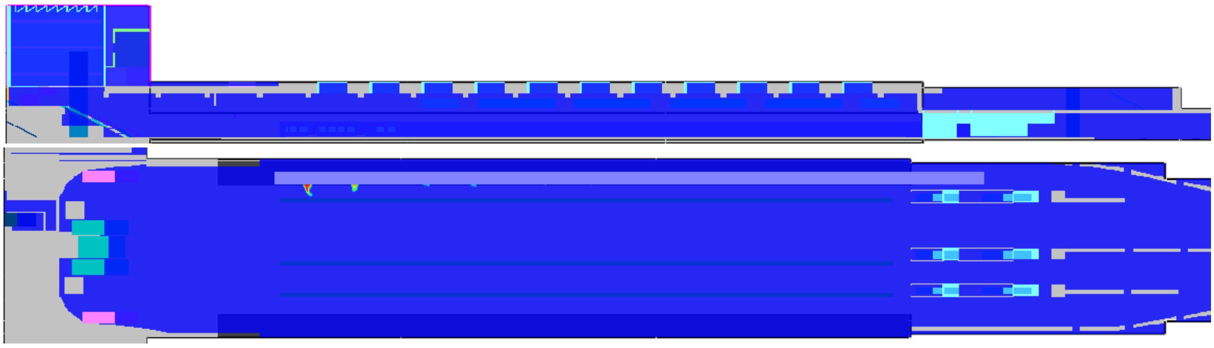
Visibility



Temperature

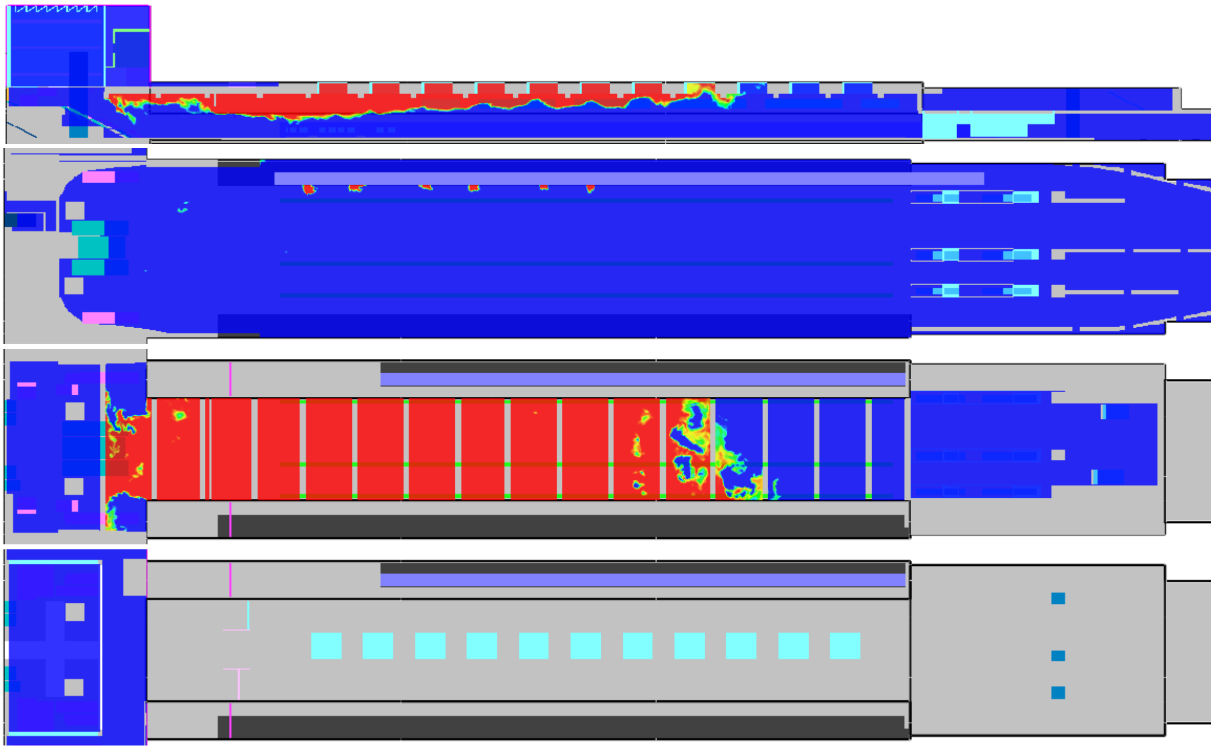


CO

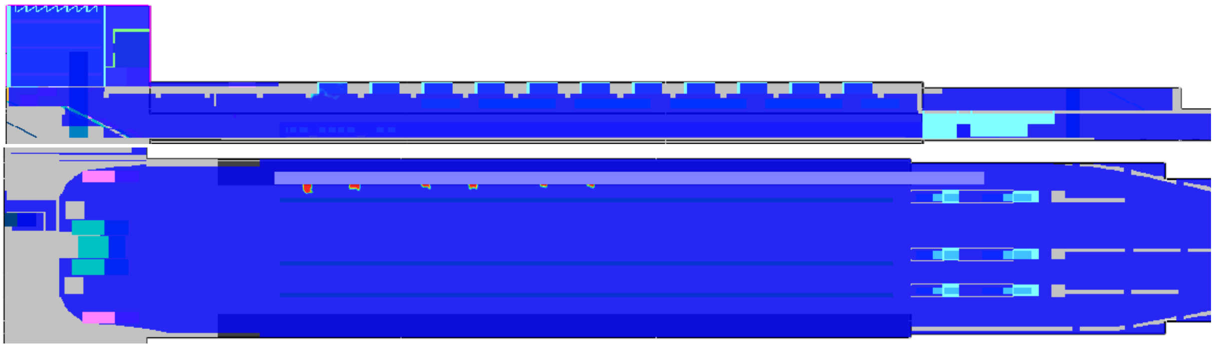


Fire Scenario 5E - Time = 480 seconds

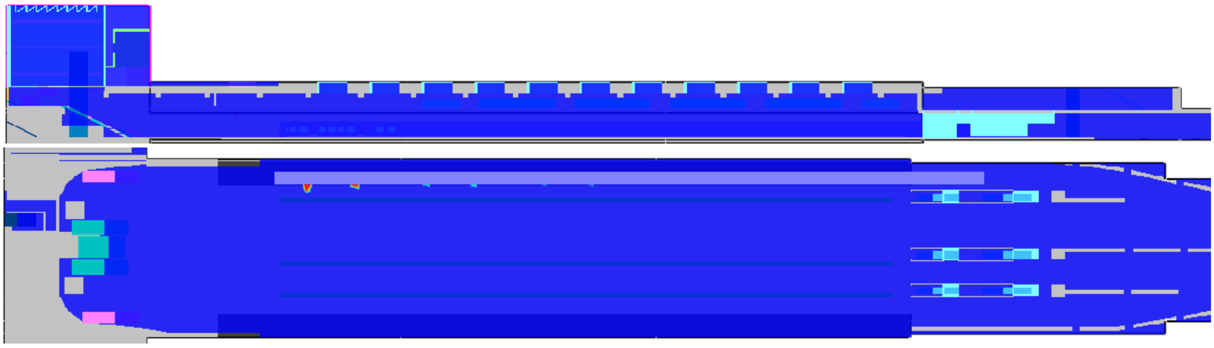
Visibility



Temperature

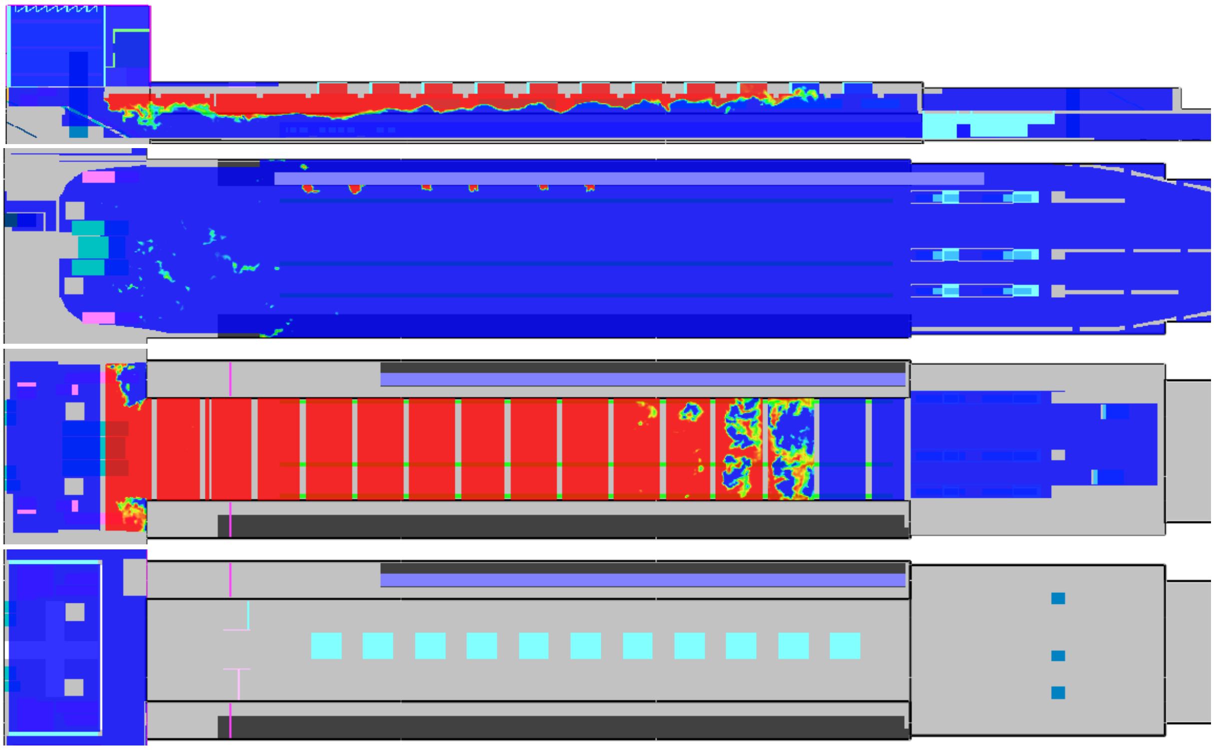


CO

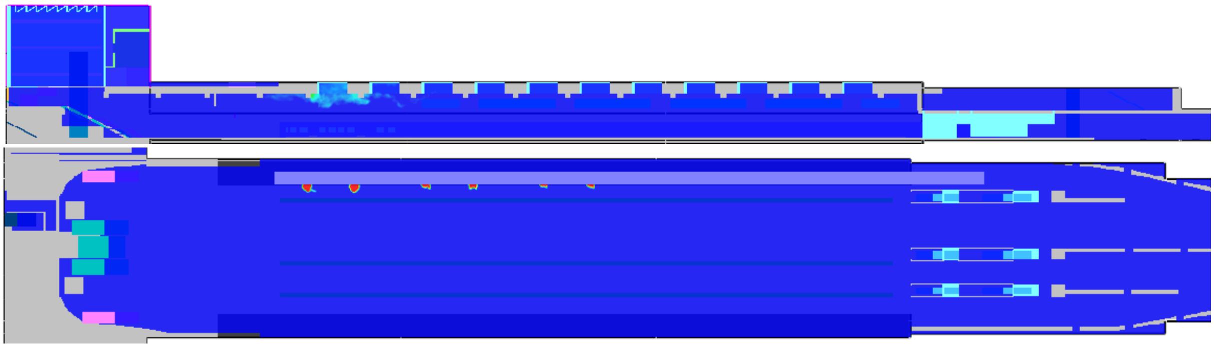


Fire Scenario 5E - Time = 600 seconds

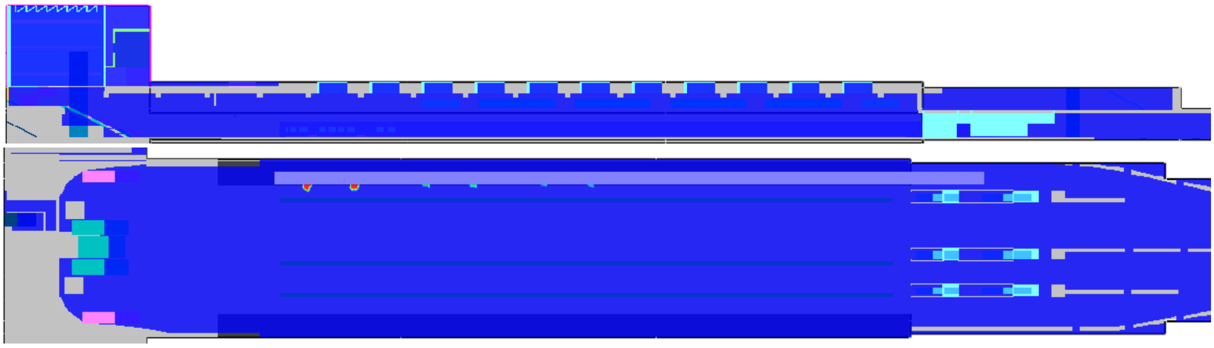
Visibility



Temperature

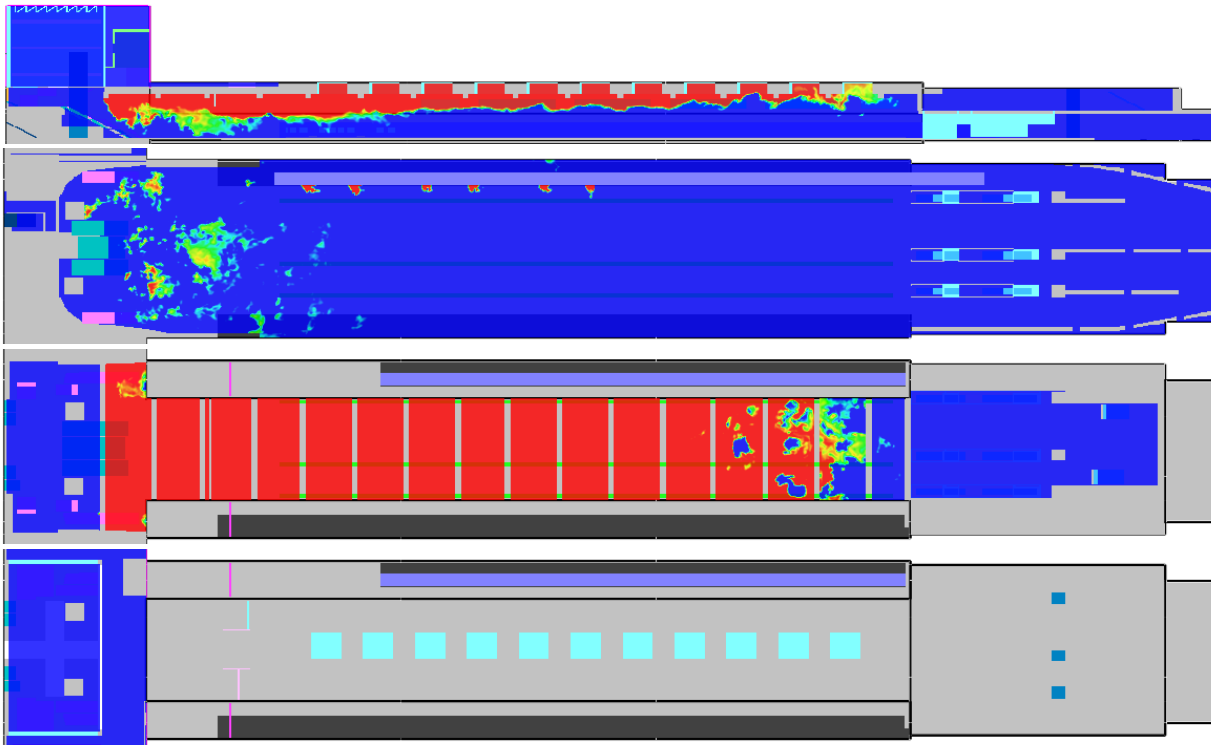


CO

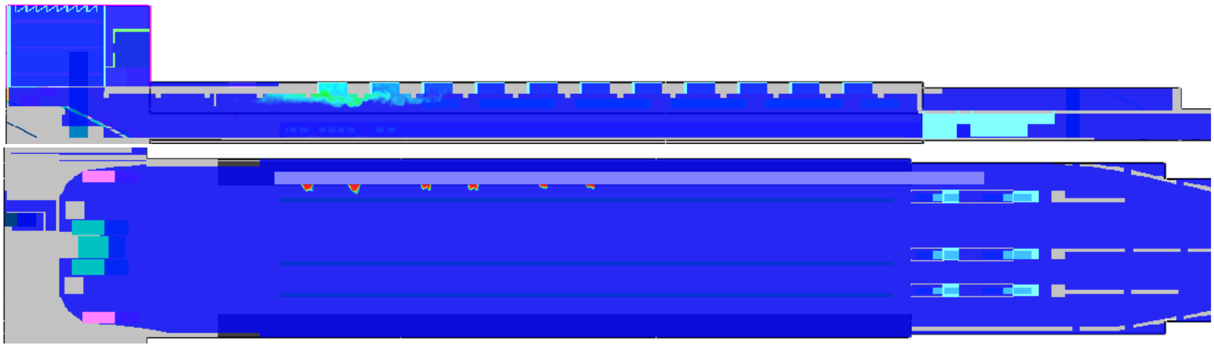


Fire Scenario 5E - Time = 720 seconds

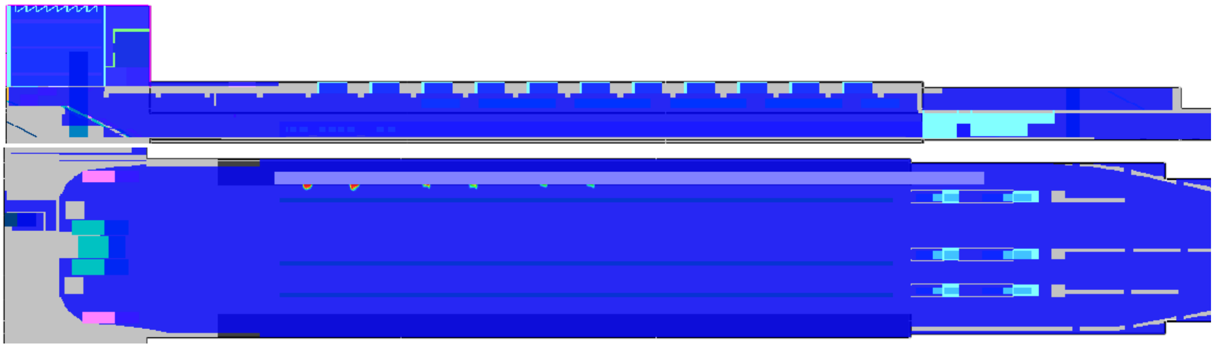
Visibility



Temperature

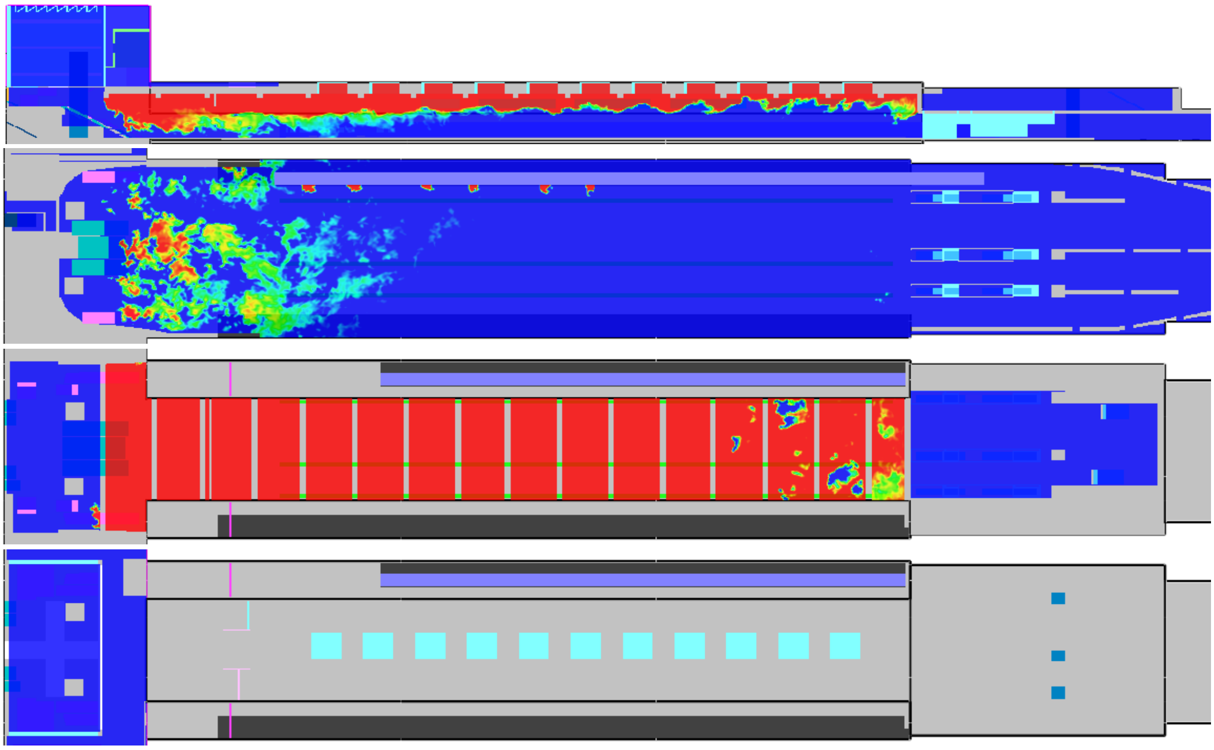


CO

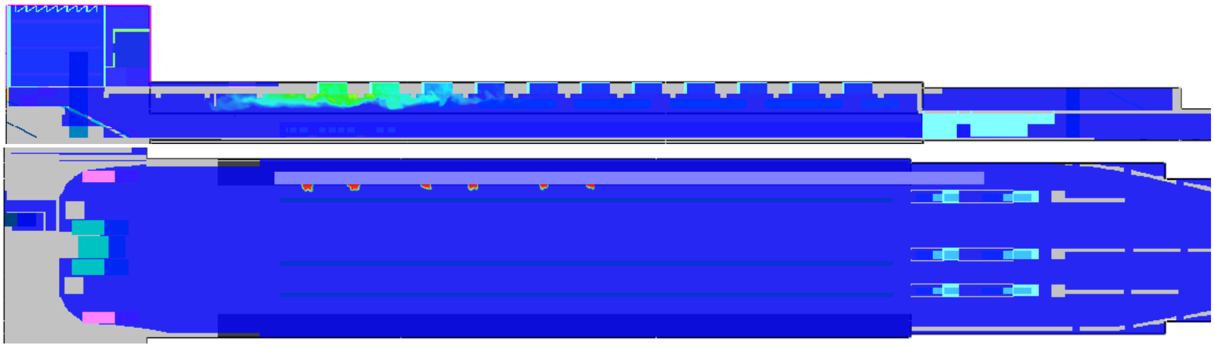


Fire Scenario 5E - Time = 840 seconds

Visibility



Temperature



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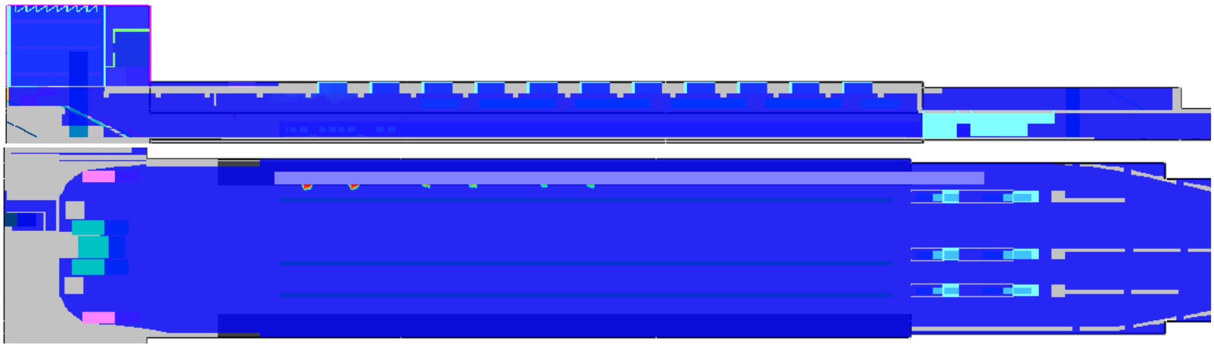
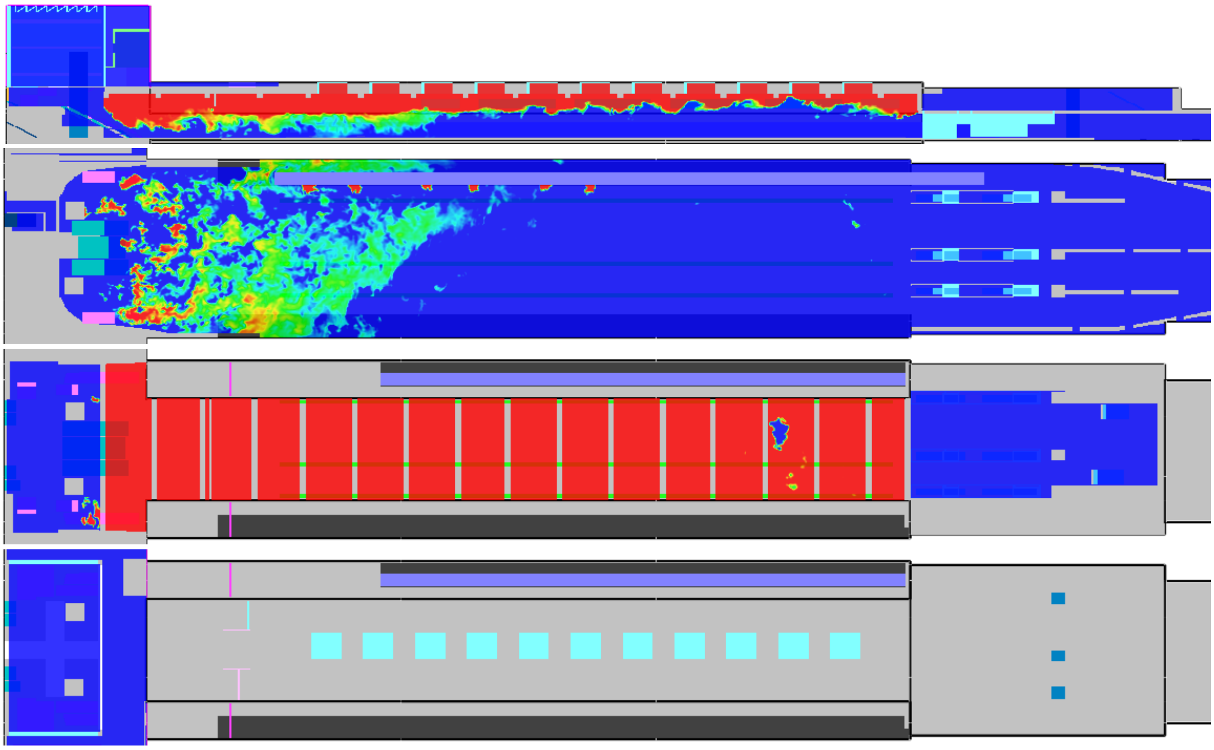
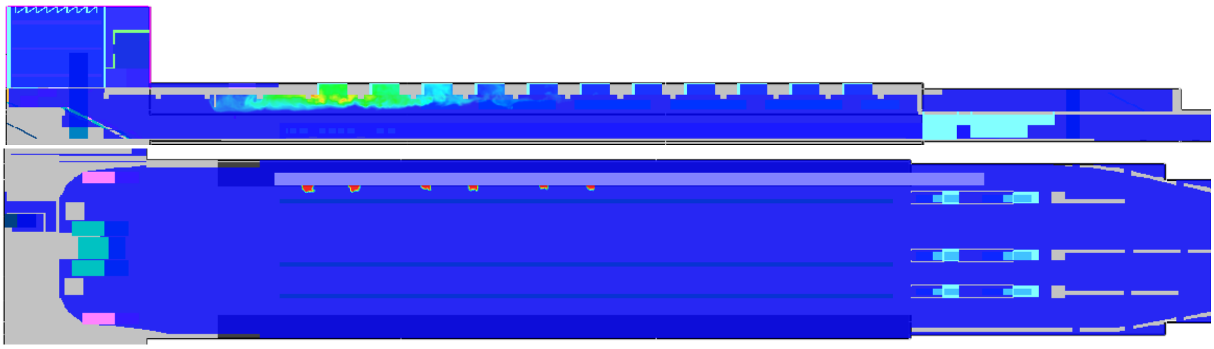


Fire Scenario 5E - Time = 960 seconds

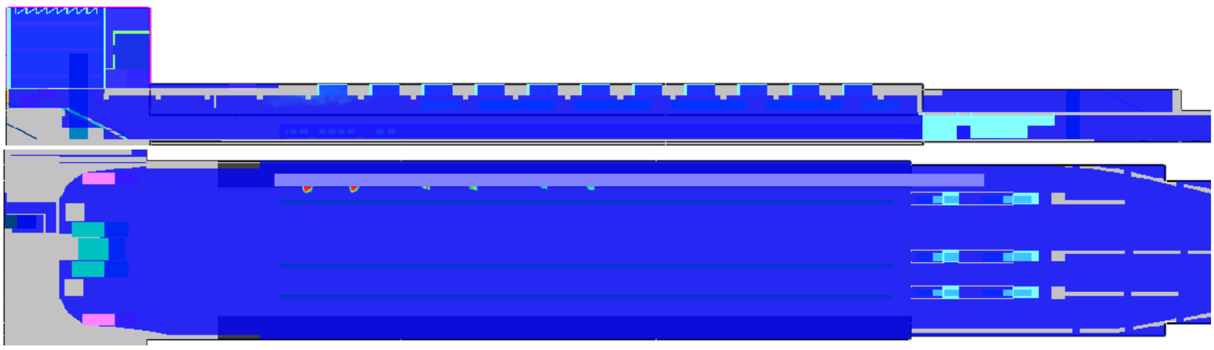
Visibility



Temperature

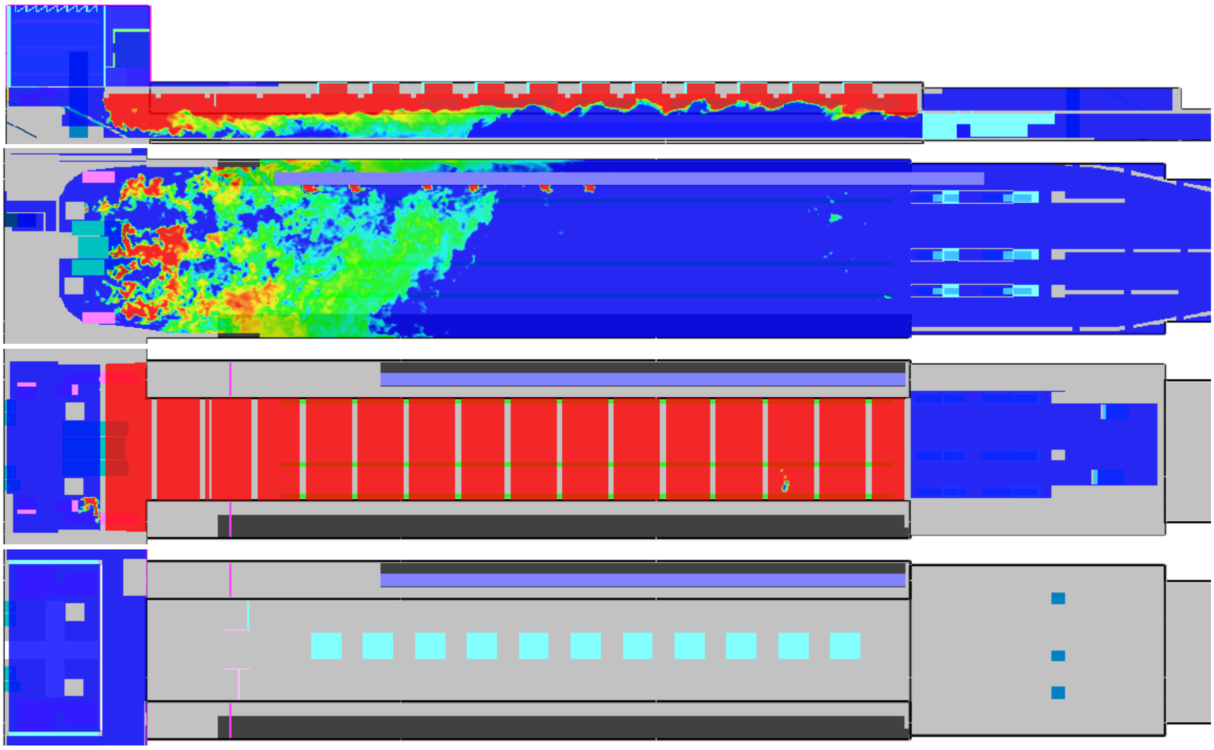


CO

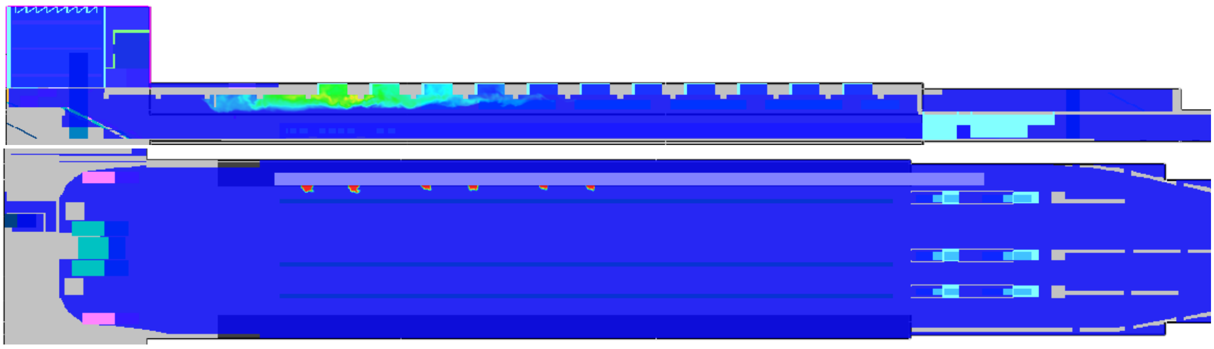


Fire Scenario 5E - Time = 1,200 seconds

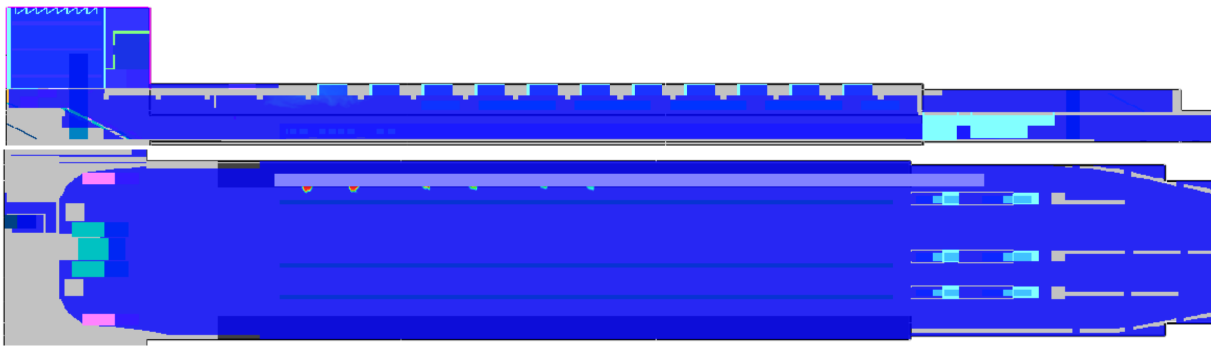
Visibility

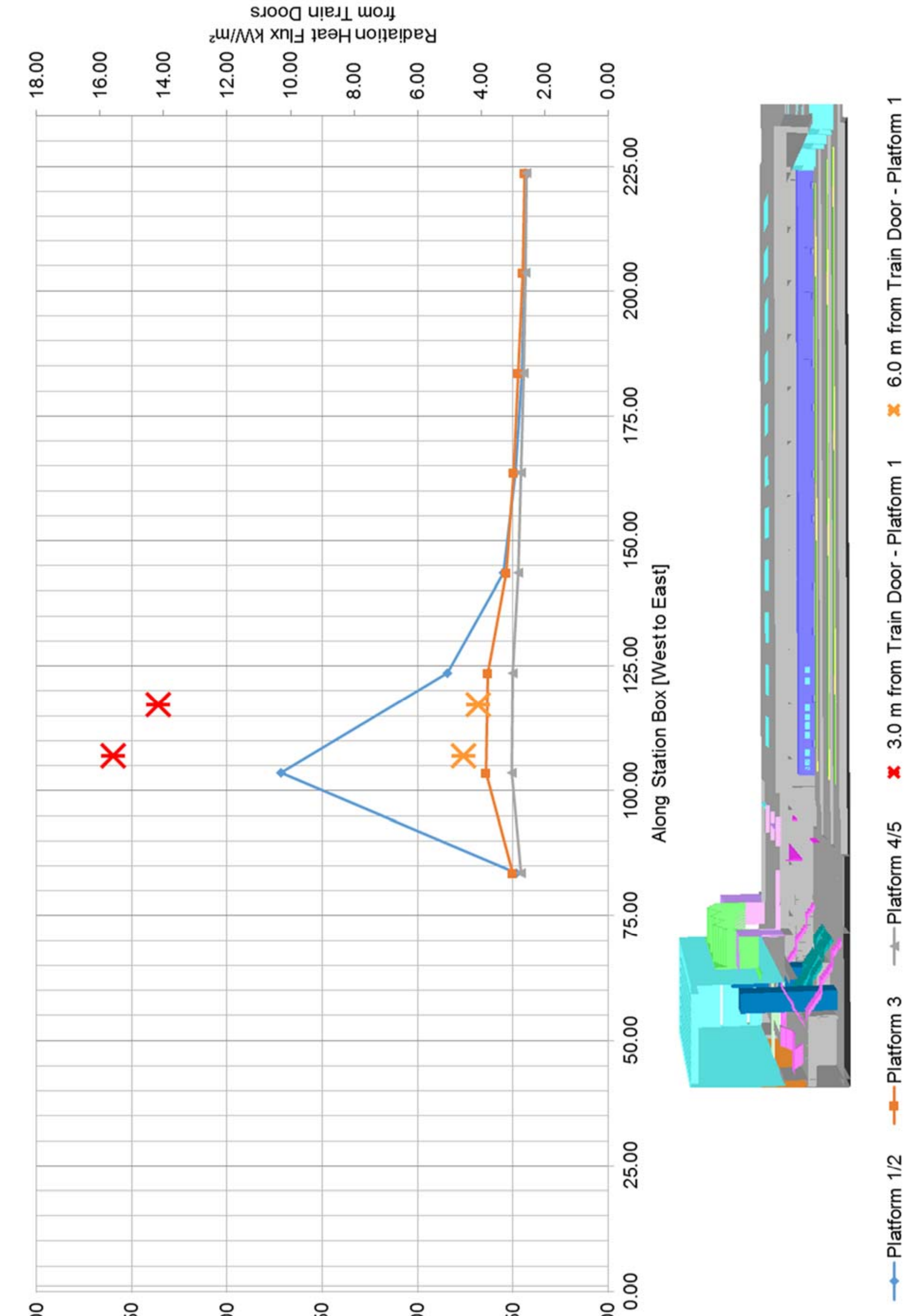


Temperature



CO

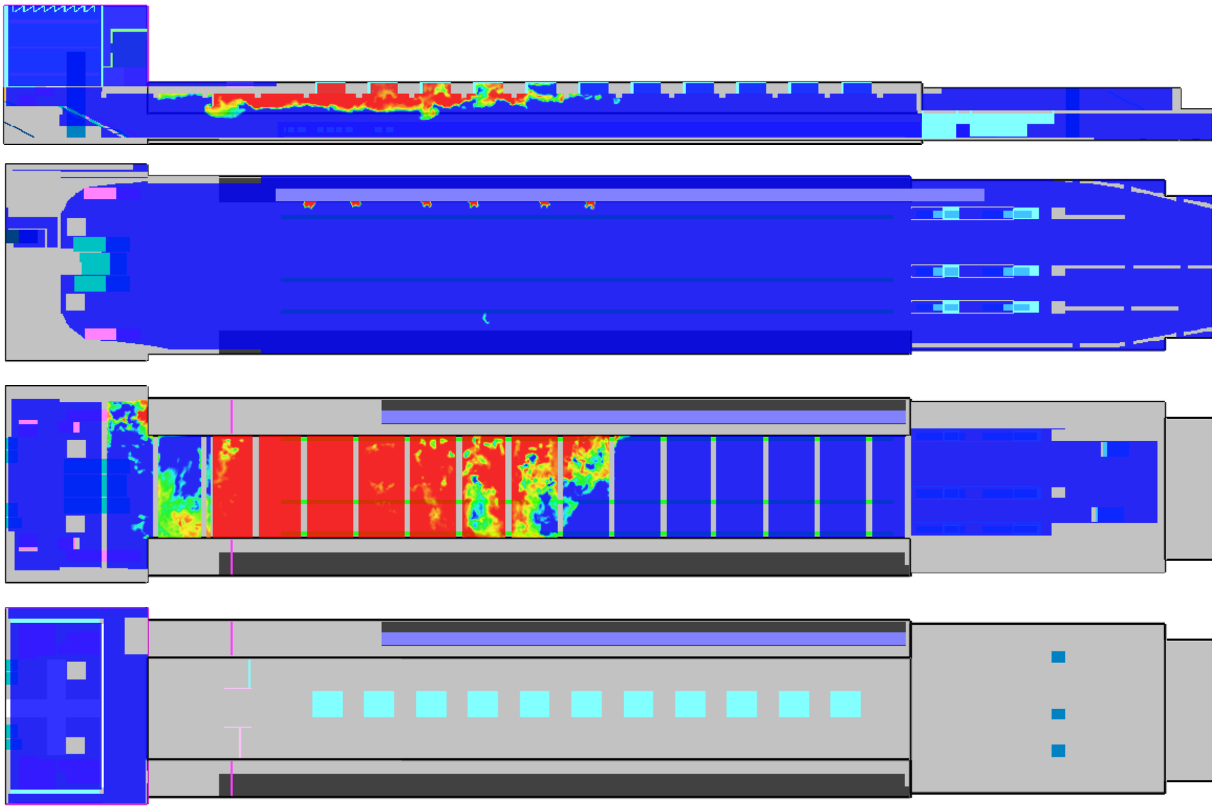




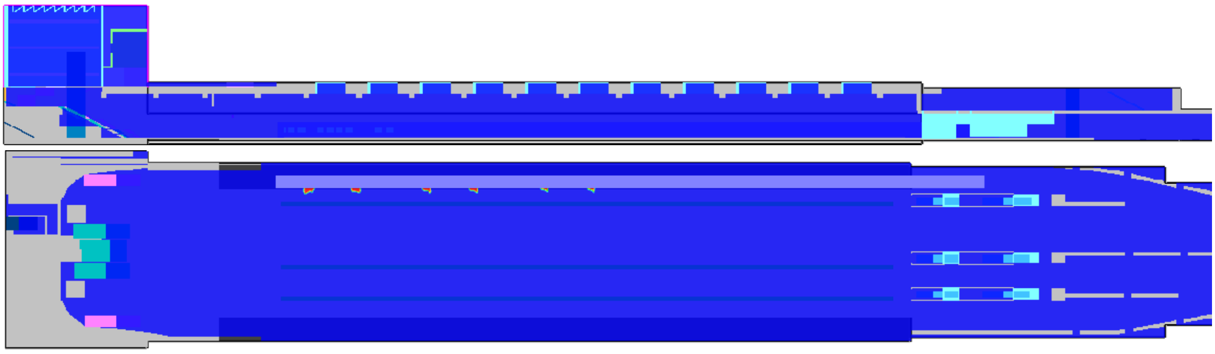
Radiation Heat Flux kW/m²
Radiation Heat Flux kW/m² from Train Doors
Along Station Box [West to East]
3.00
2.50
2.00
1.50
1.00
0.50
0.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
Platform 1/2
Platform 3
Platform 4/5
3.0 m from Train Door - Platform 1
6.0 m from Train Door - Platform 1

Fire Scenario 6E - Time = 120 seconds

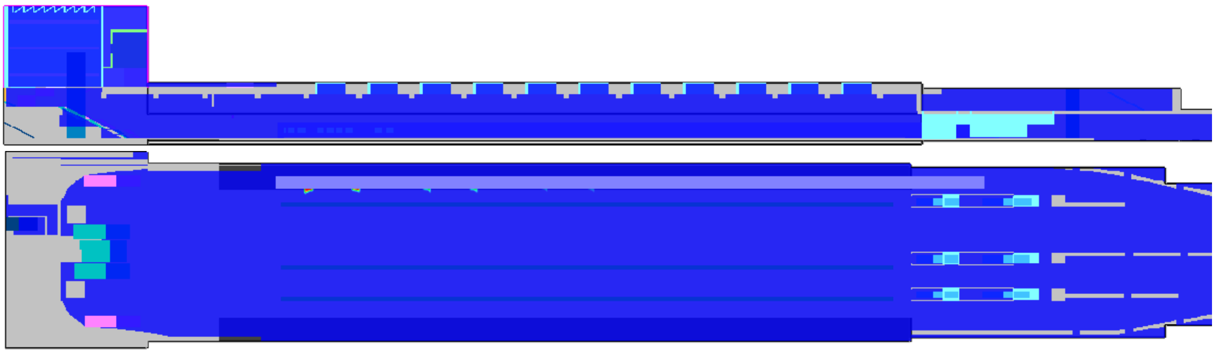
Visibility



Temperature

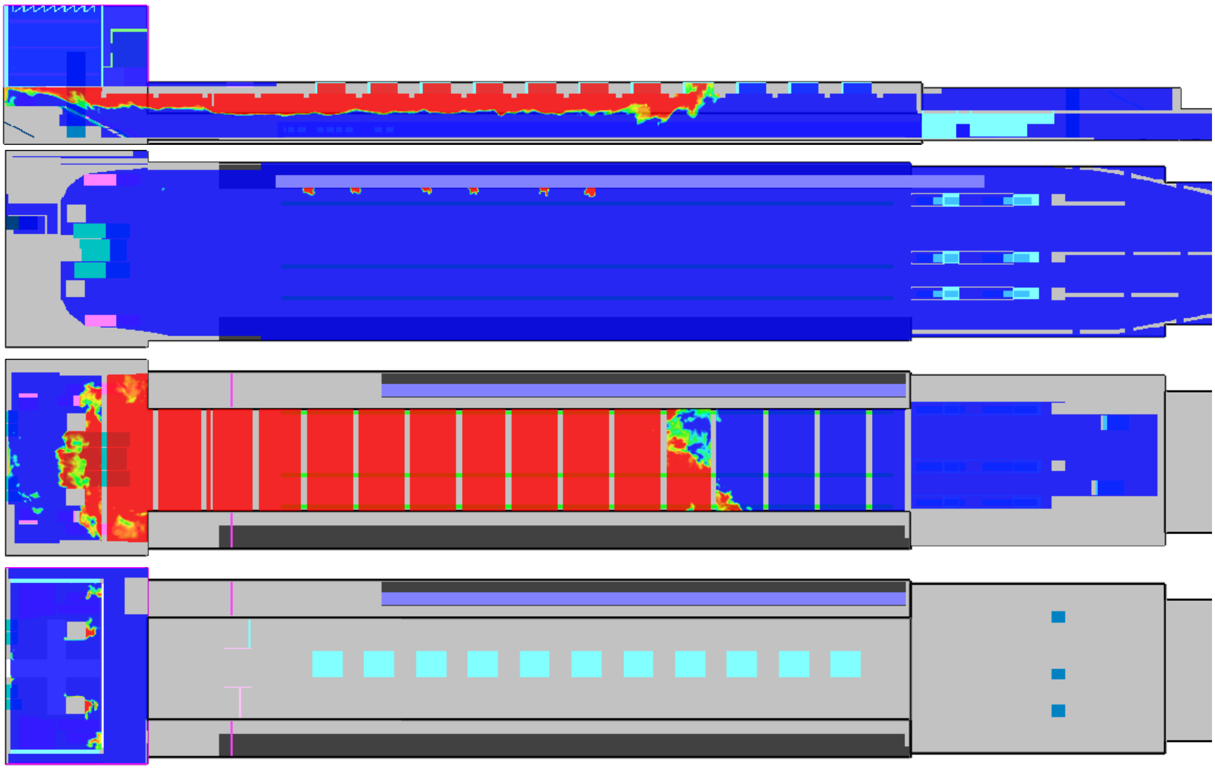


CO

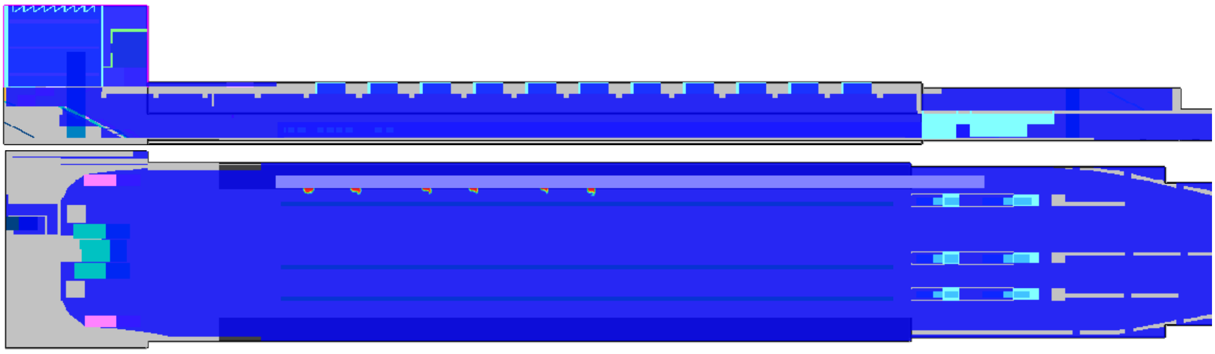


Fire Scenario 6E - Time = 240 seconds

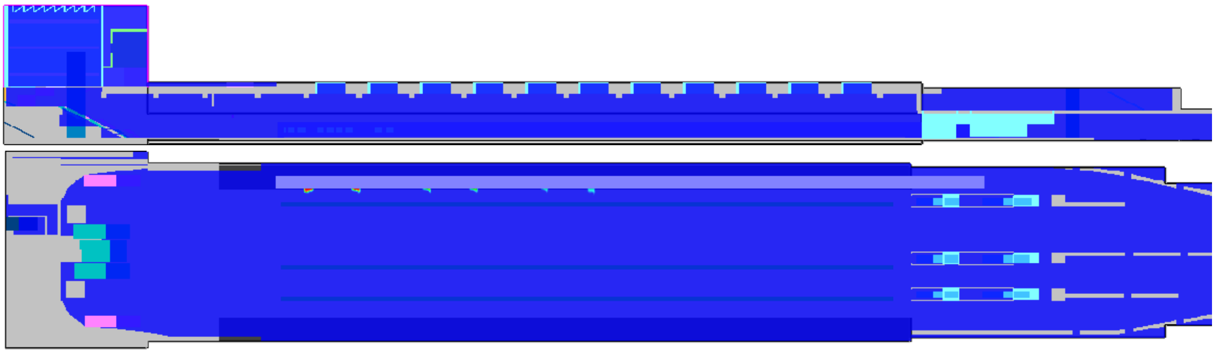
Visibility



Temperature

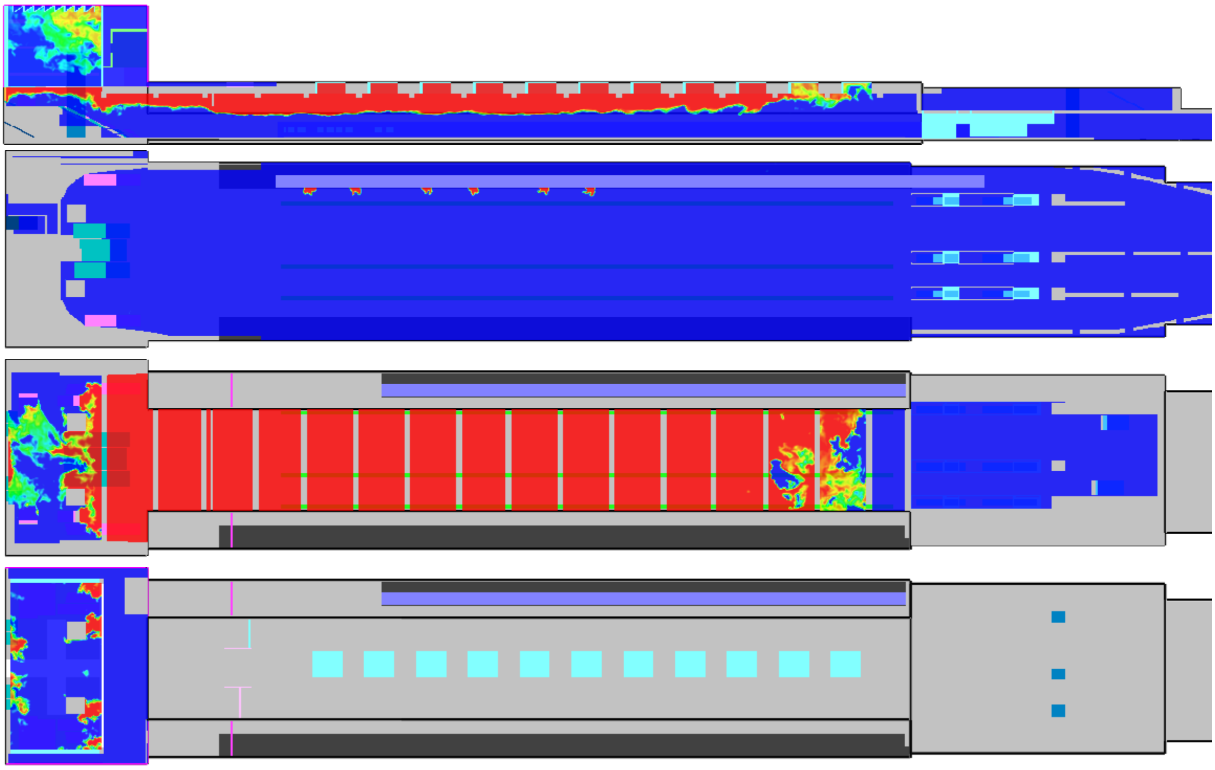


CO

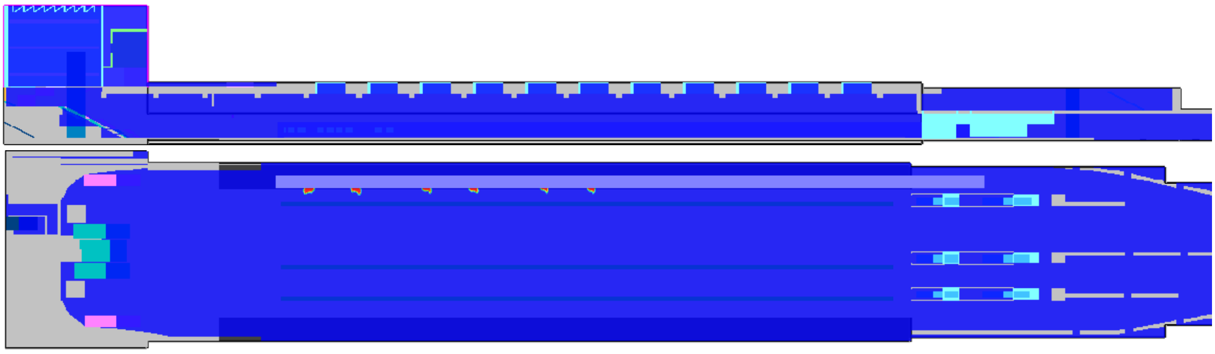


Fire Scenario 6E - Time = 360 seconds

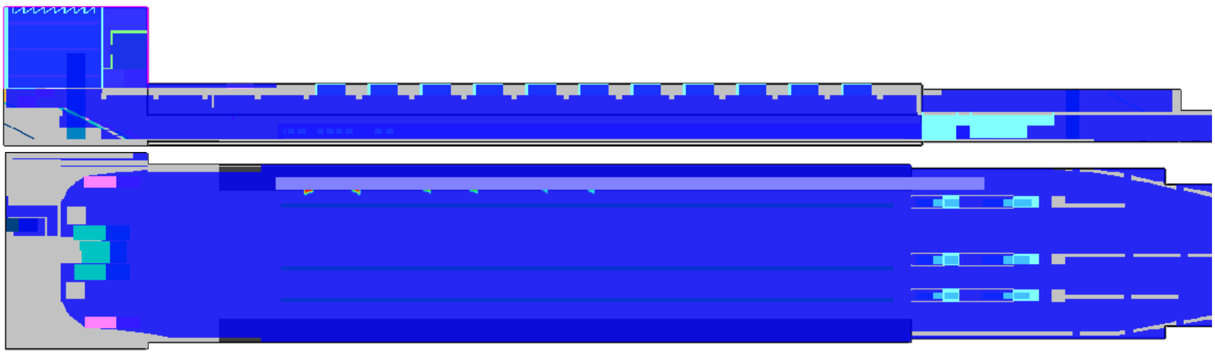
Visibility



Temperature

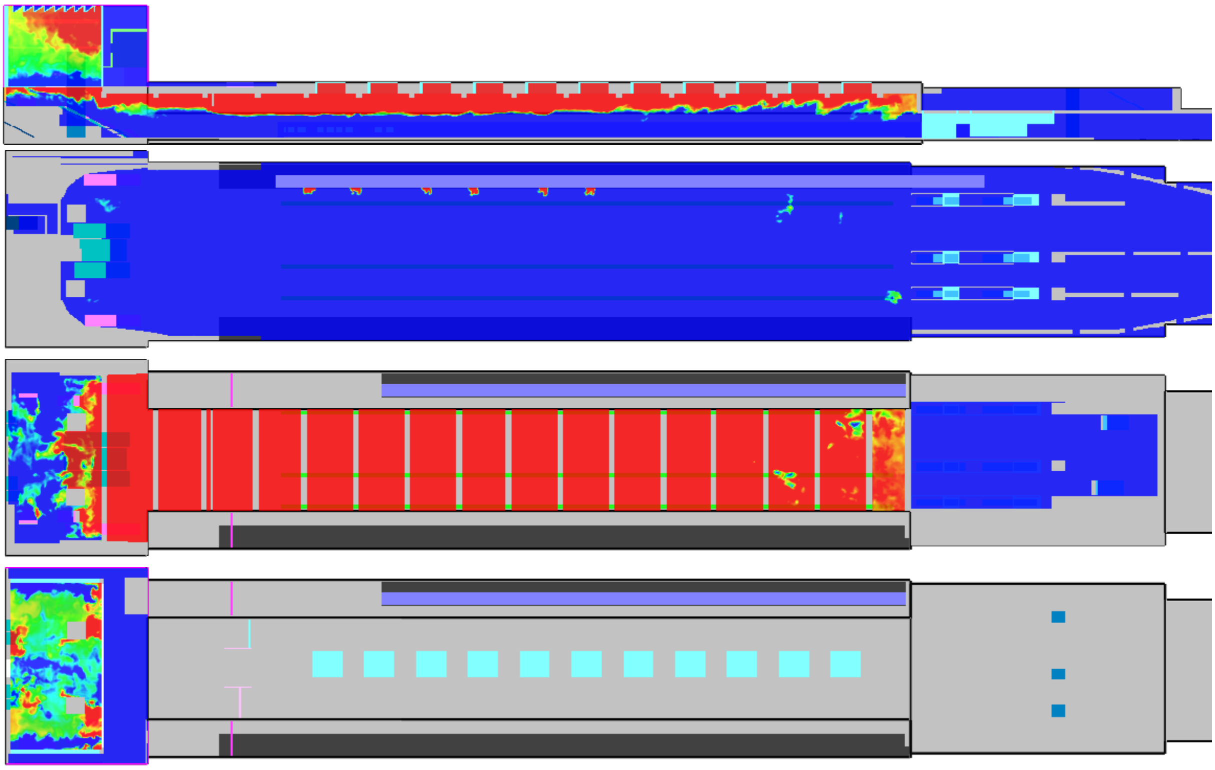


CO

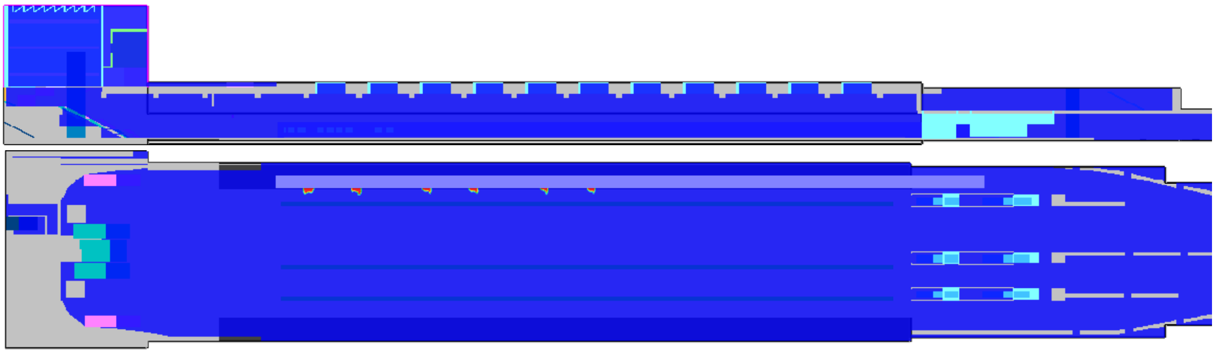


Fire Scenario 6E - Time = 480 seconds

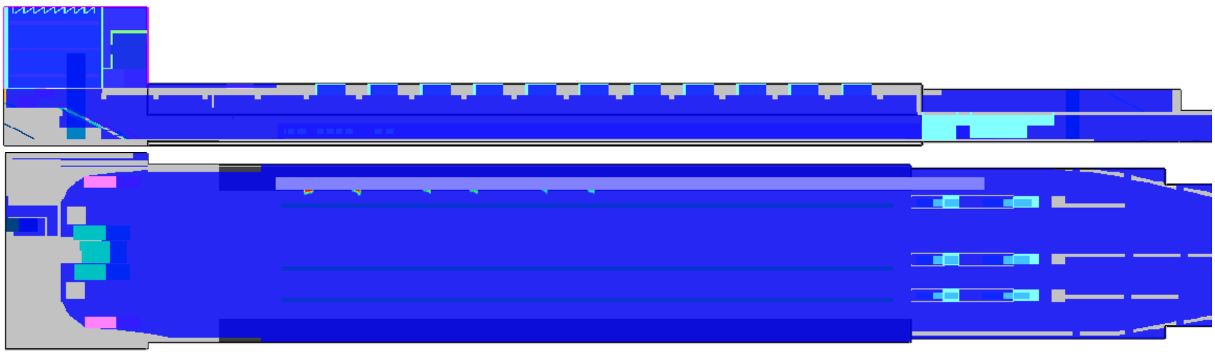
Visibility



Temperature

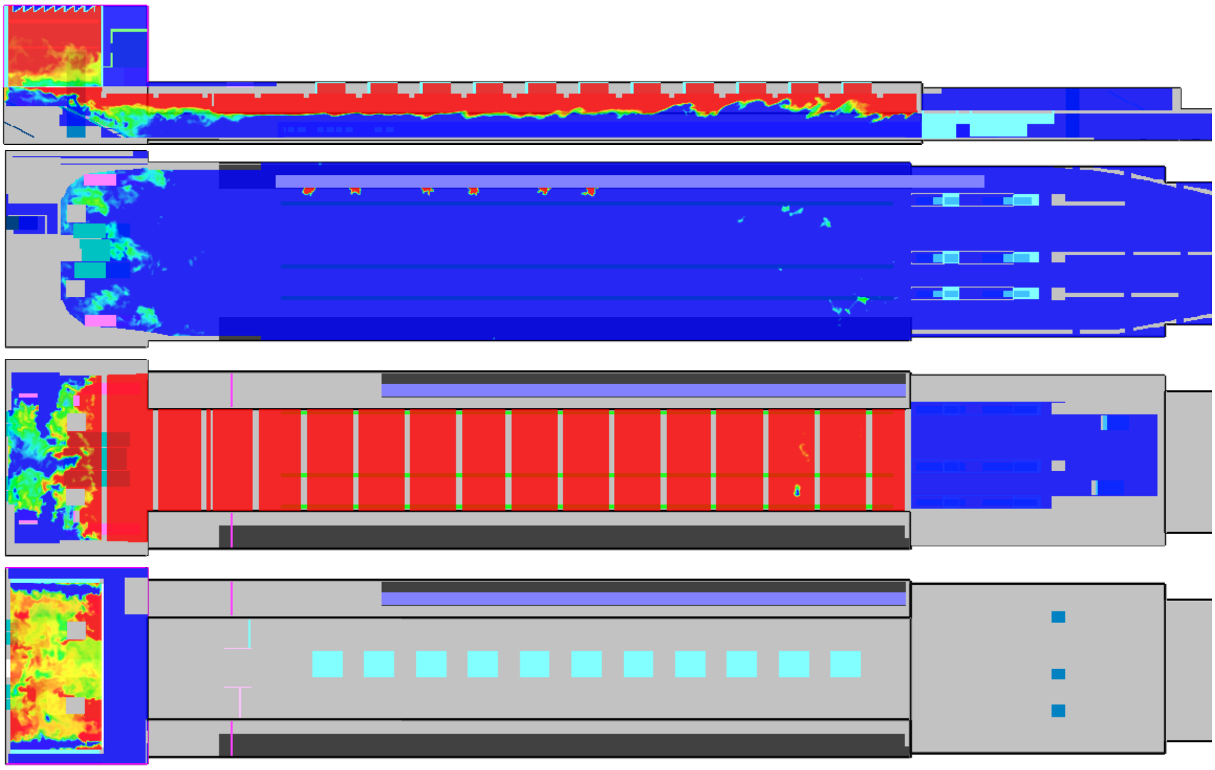


CO

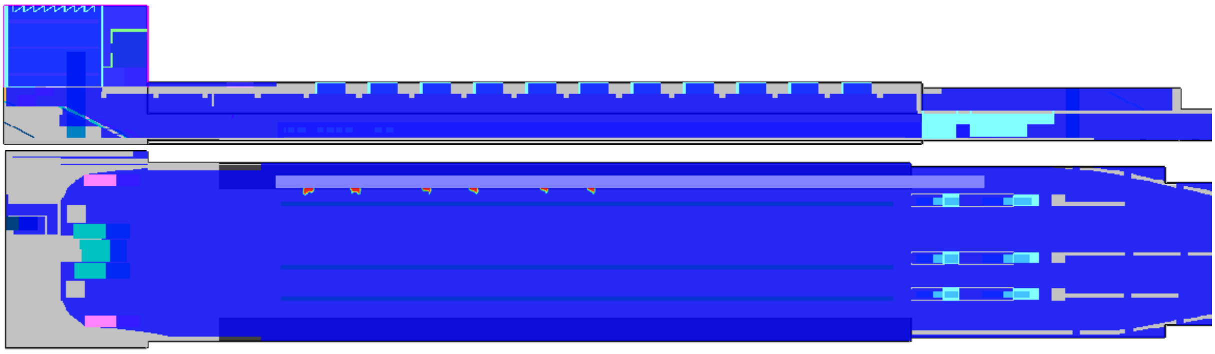


Fire Scenario 6E - Time = 600 seconds

Visibility



Temperature



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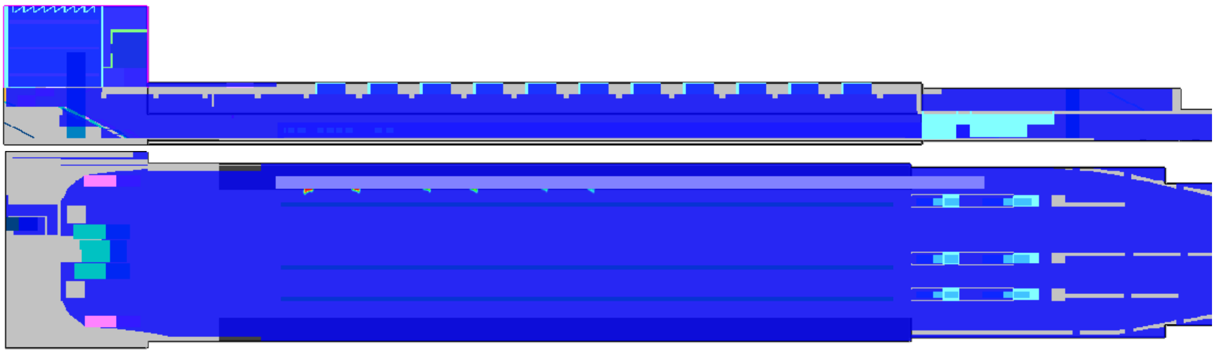
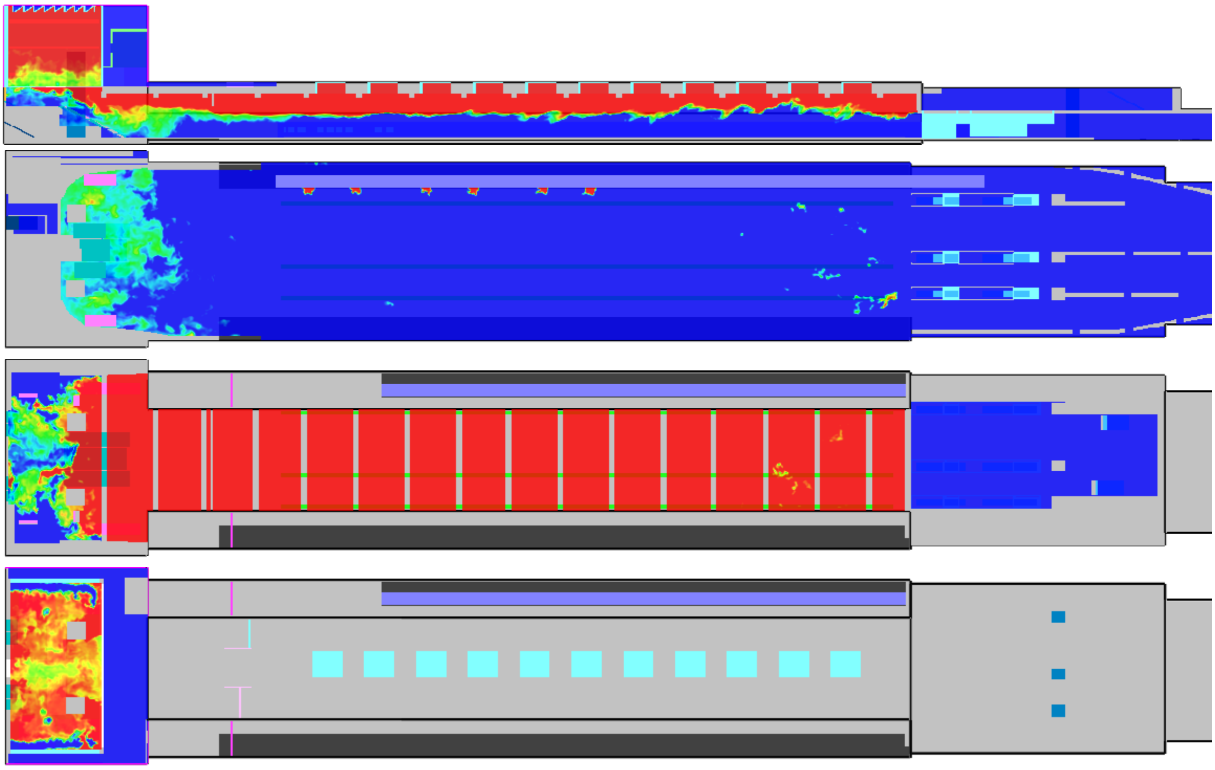
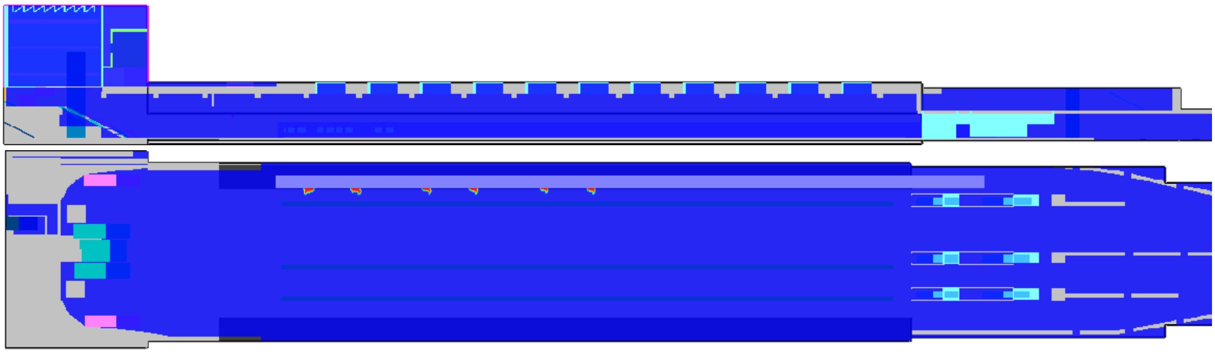


Fire Scenario 6E - Time = 720 seconds

Visibility



Temperature



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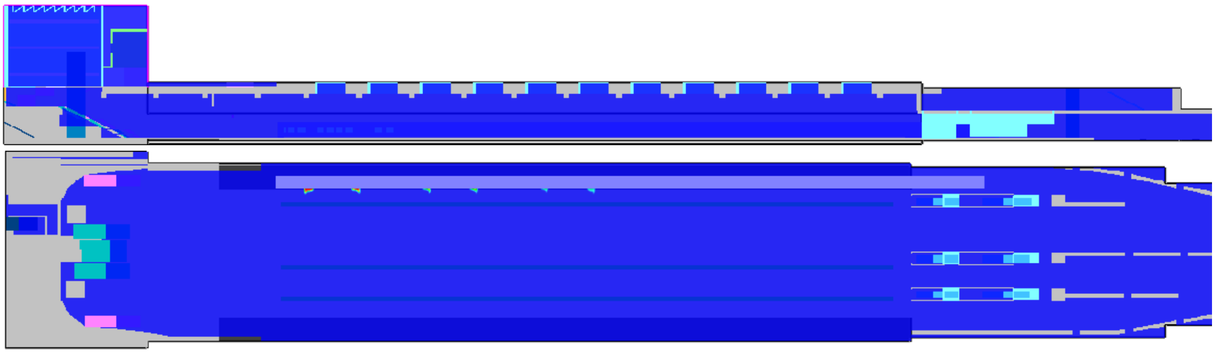
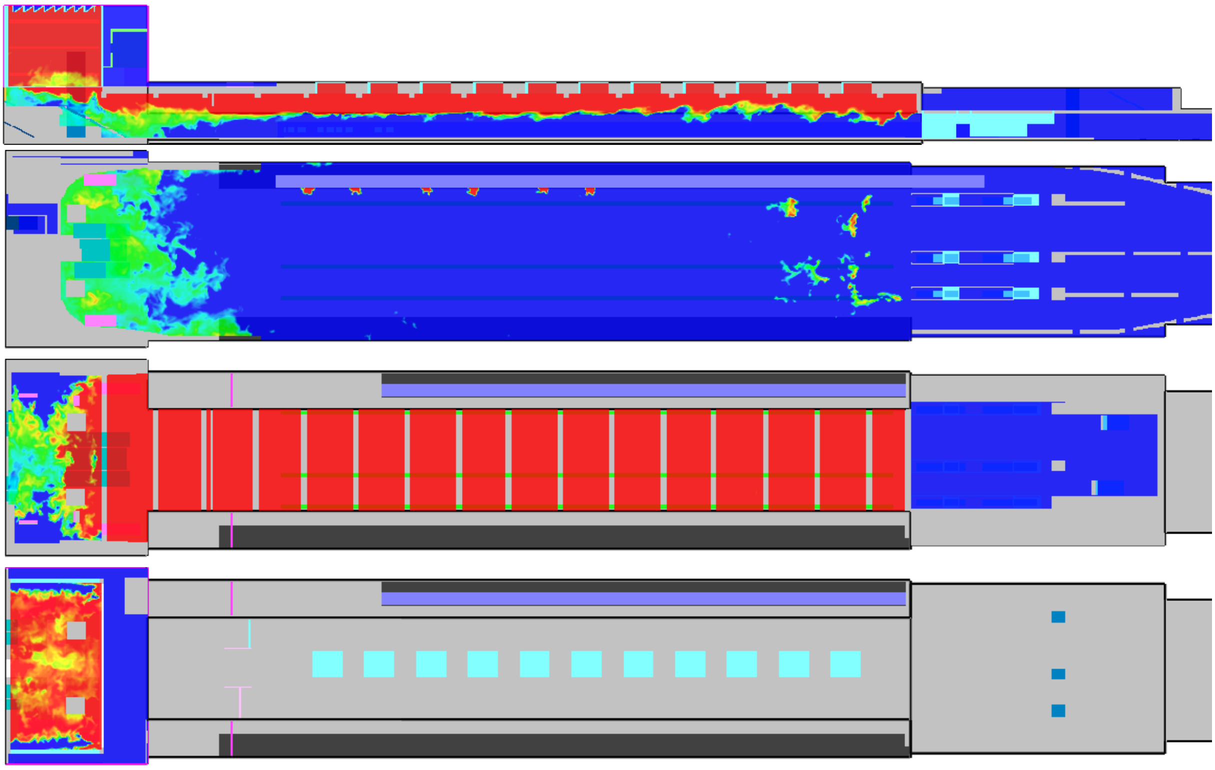
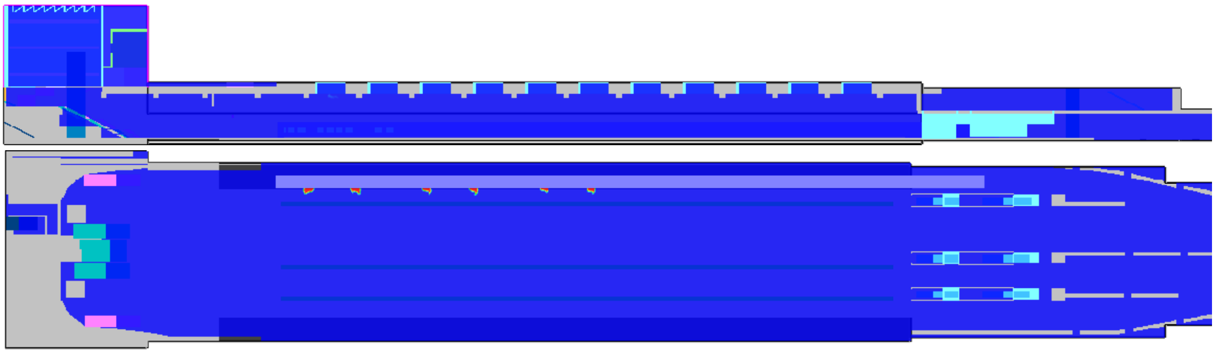


Fire Scenario 6E - Time = 840 seconds

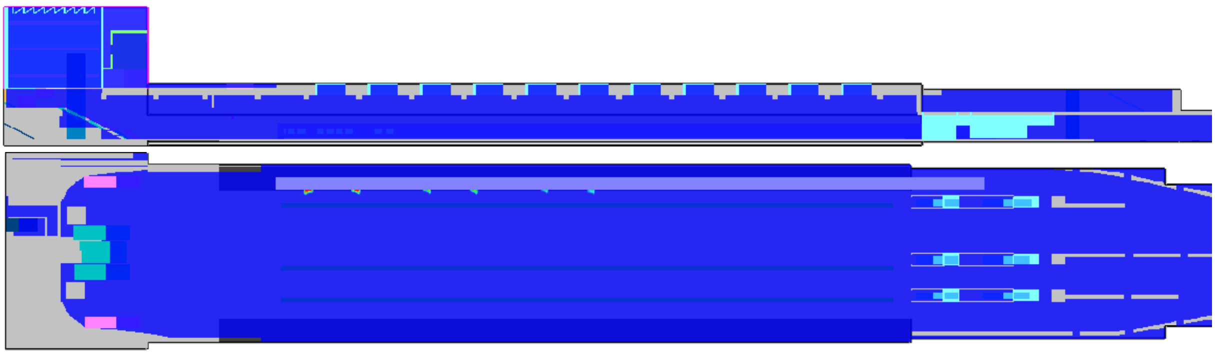
Visibility



Temperature

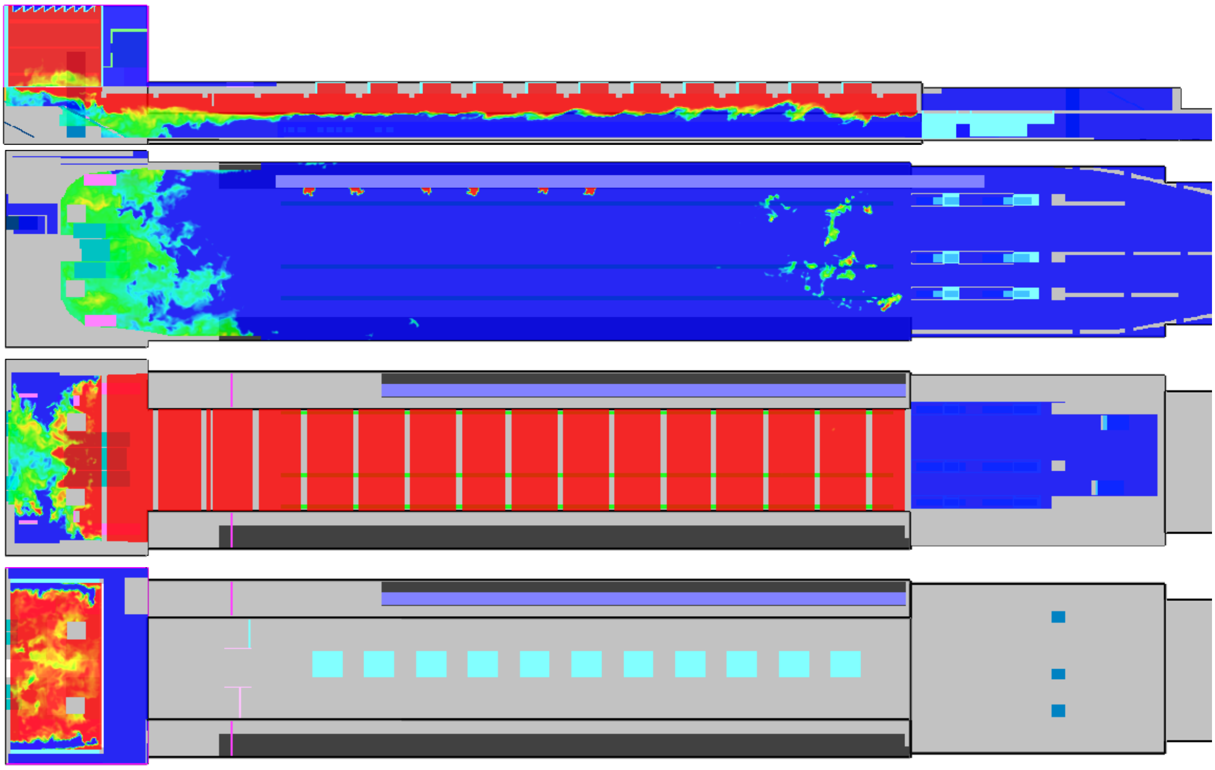


CO

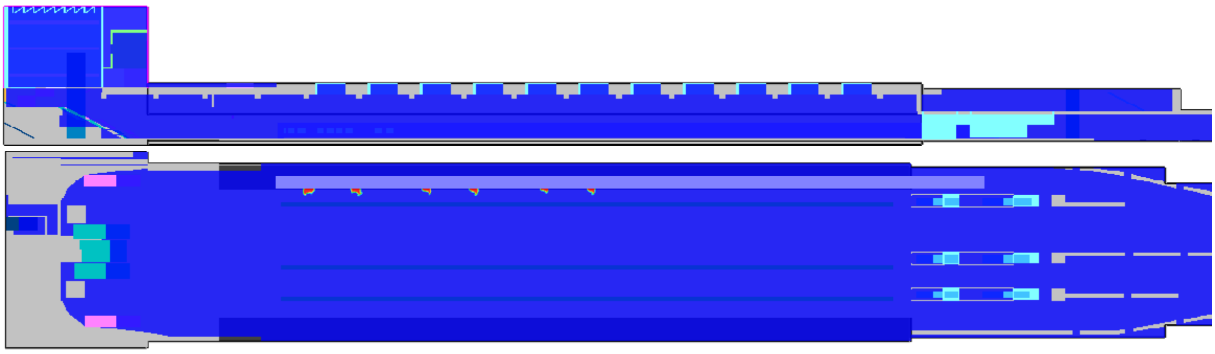


Fire Scenario 6E - Time = 846 seconds

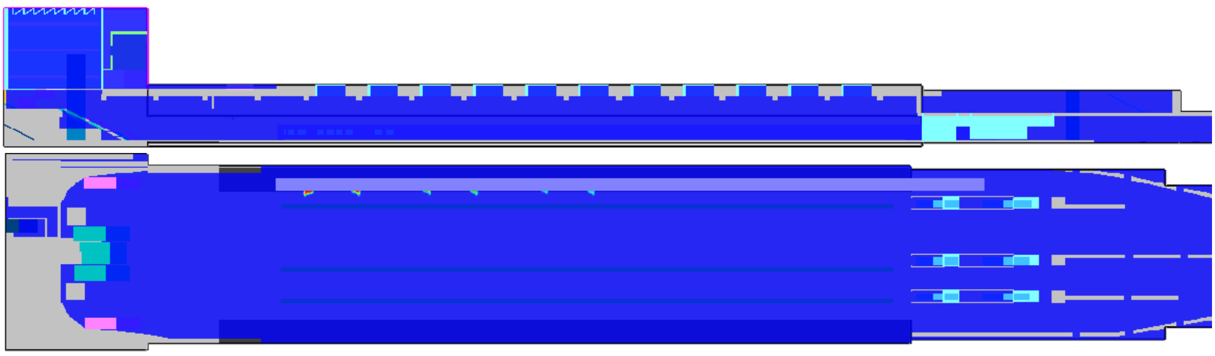
Visibility

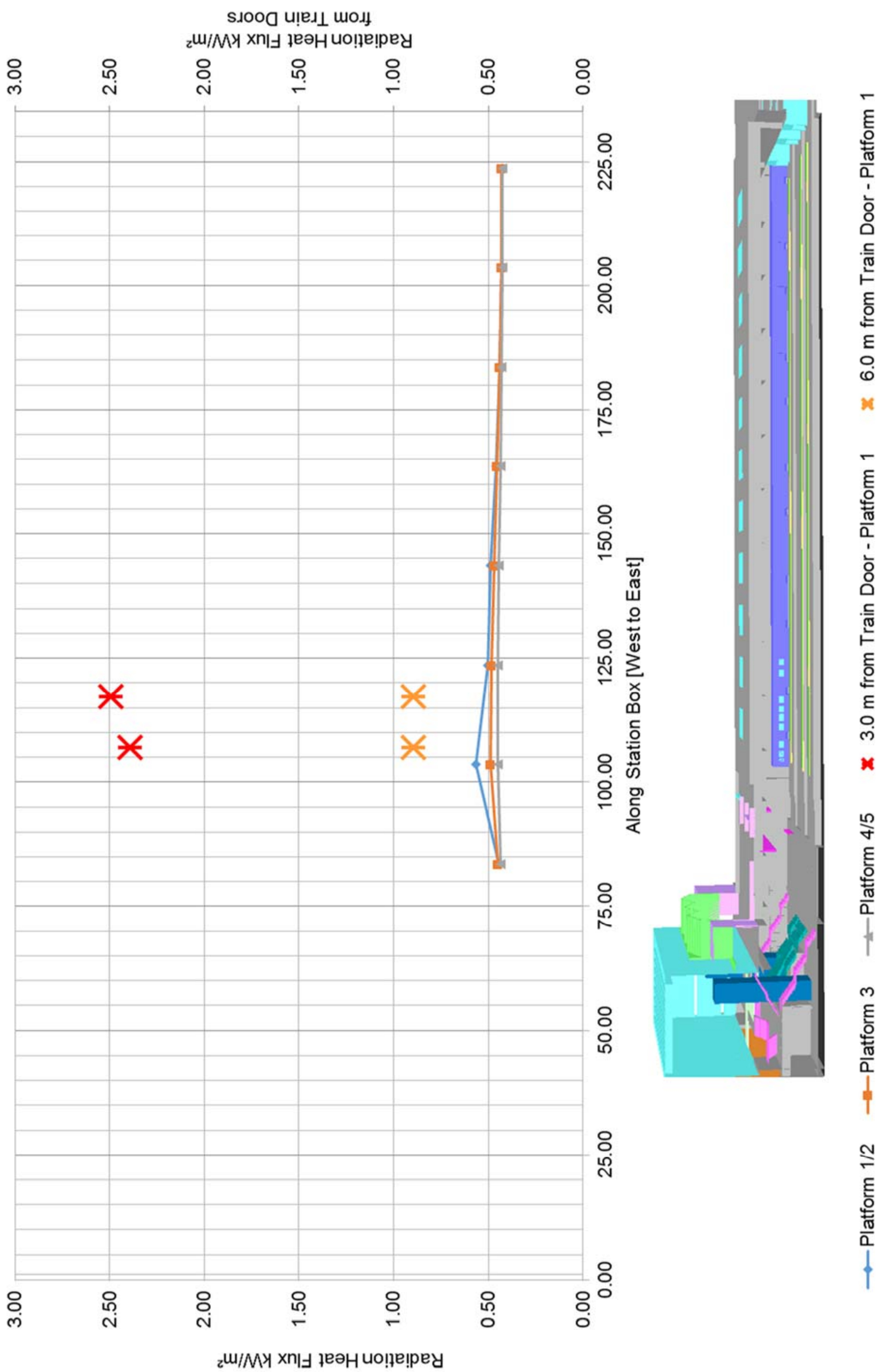


Temperature



CO

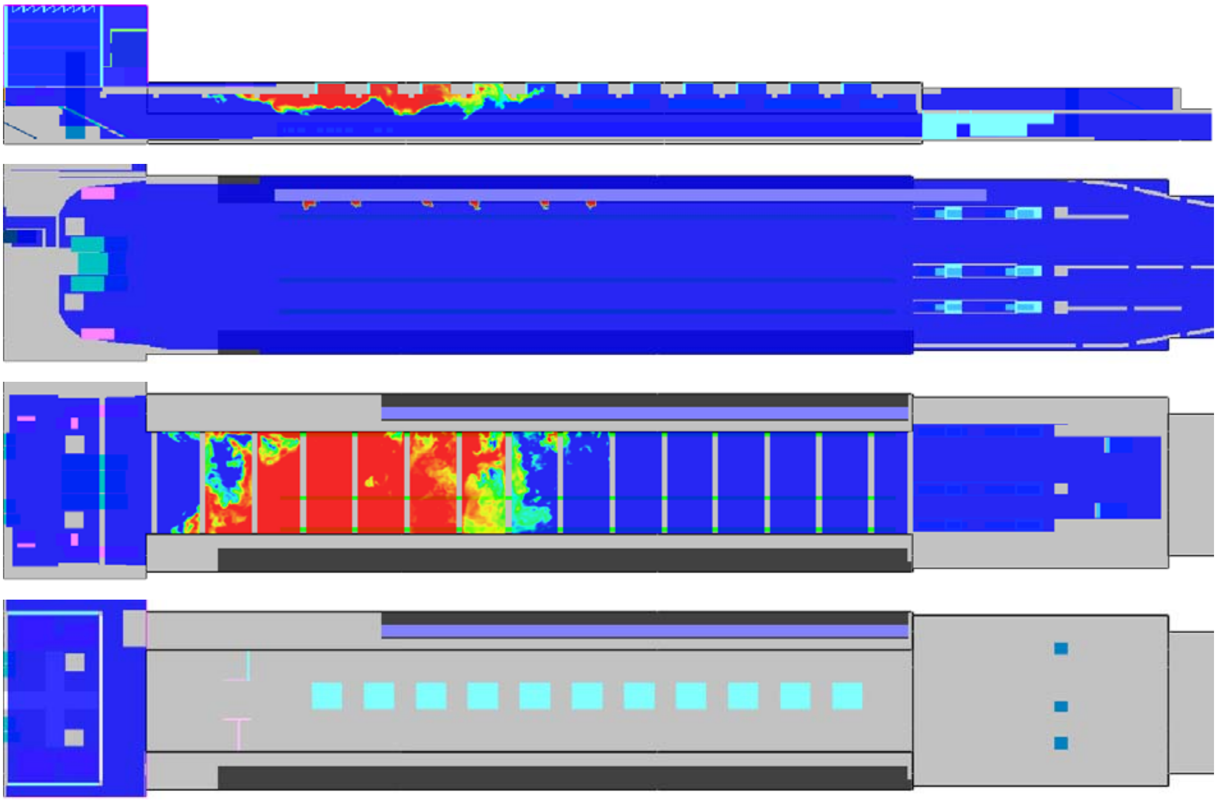




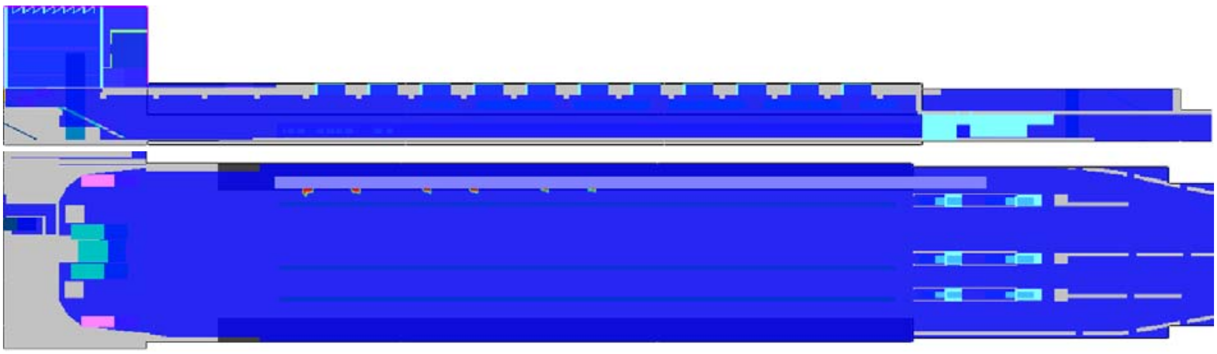
Radiation Heat Flux kW/m²
from Train Doors
Radiation Heat Flux kW/m²
Along Station Box [West to East]
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Platform 1/2
Platform 3
Platform 4/5
3.0 m from Train Door - Platform 1
6.0 m from Train Door - Platform 1

Fire Scenario 7E - Time = 120 seconds

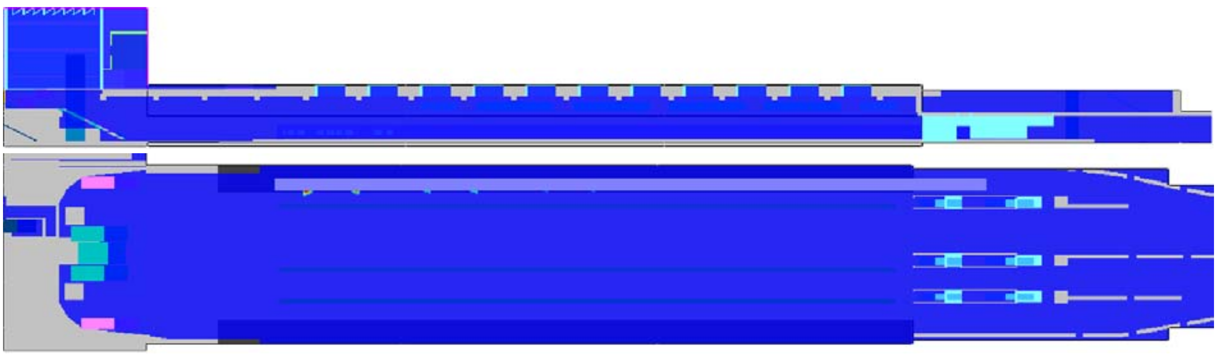
Visibility



Temperature

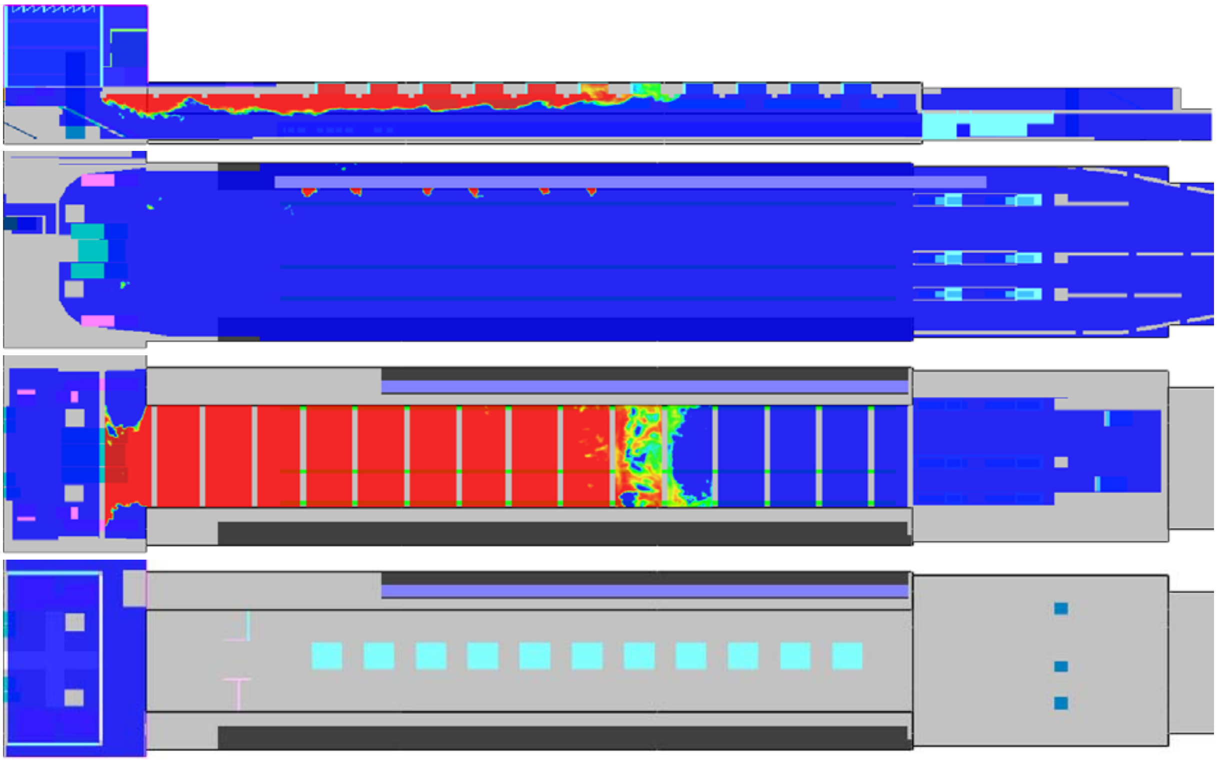


CO

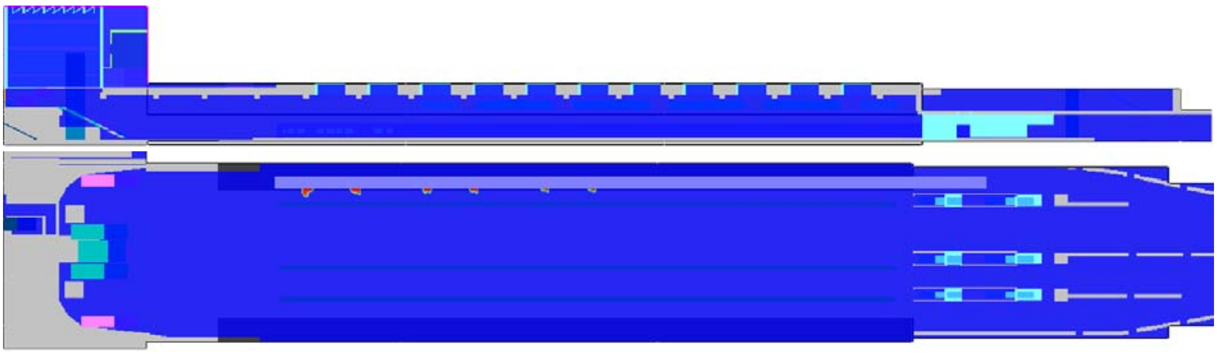


Fire Scenario 7E - Time = 240 seconds

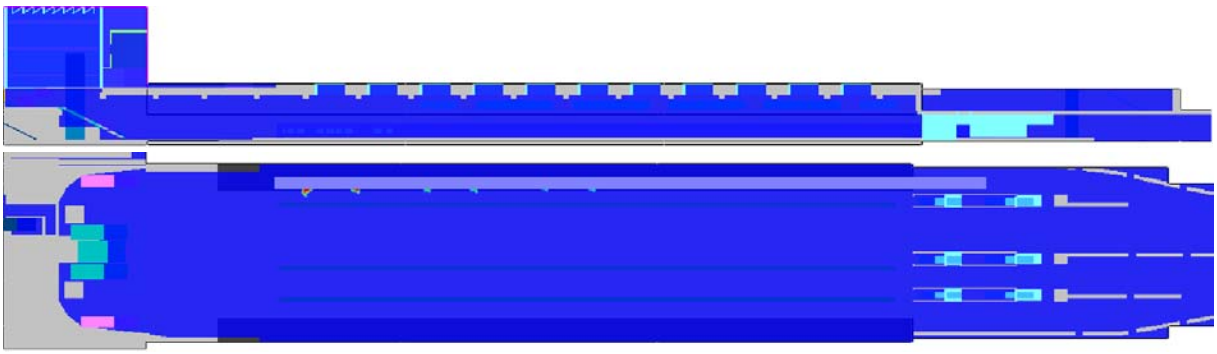
Visibility



Temperature

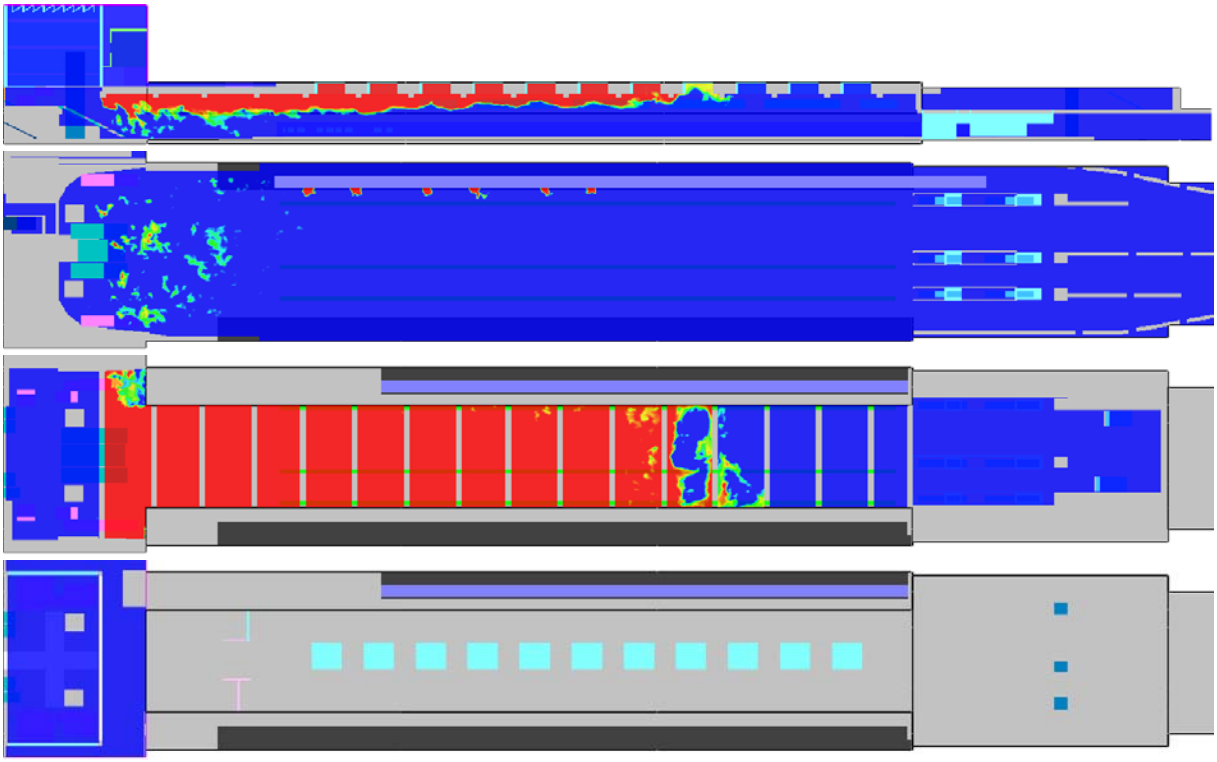


CO

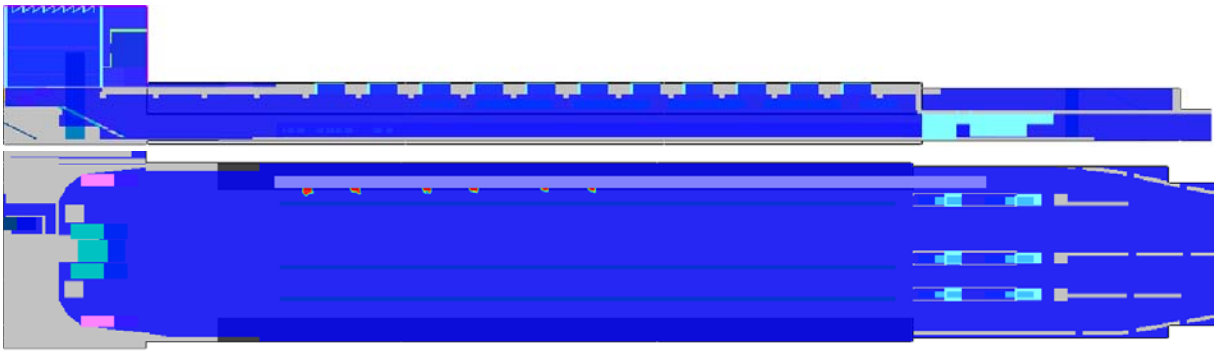


Fire Scenario 7E - Time = 360 seconds

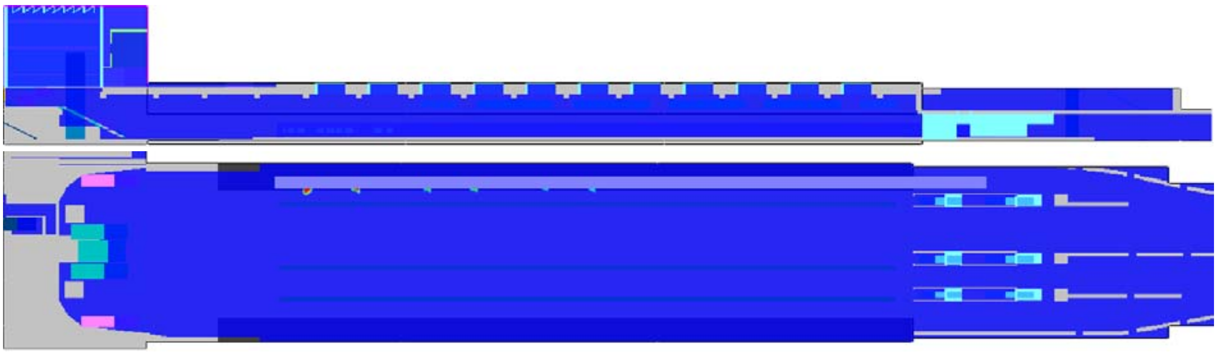
Visibility



Temperature

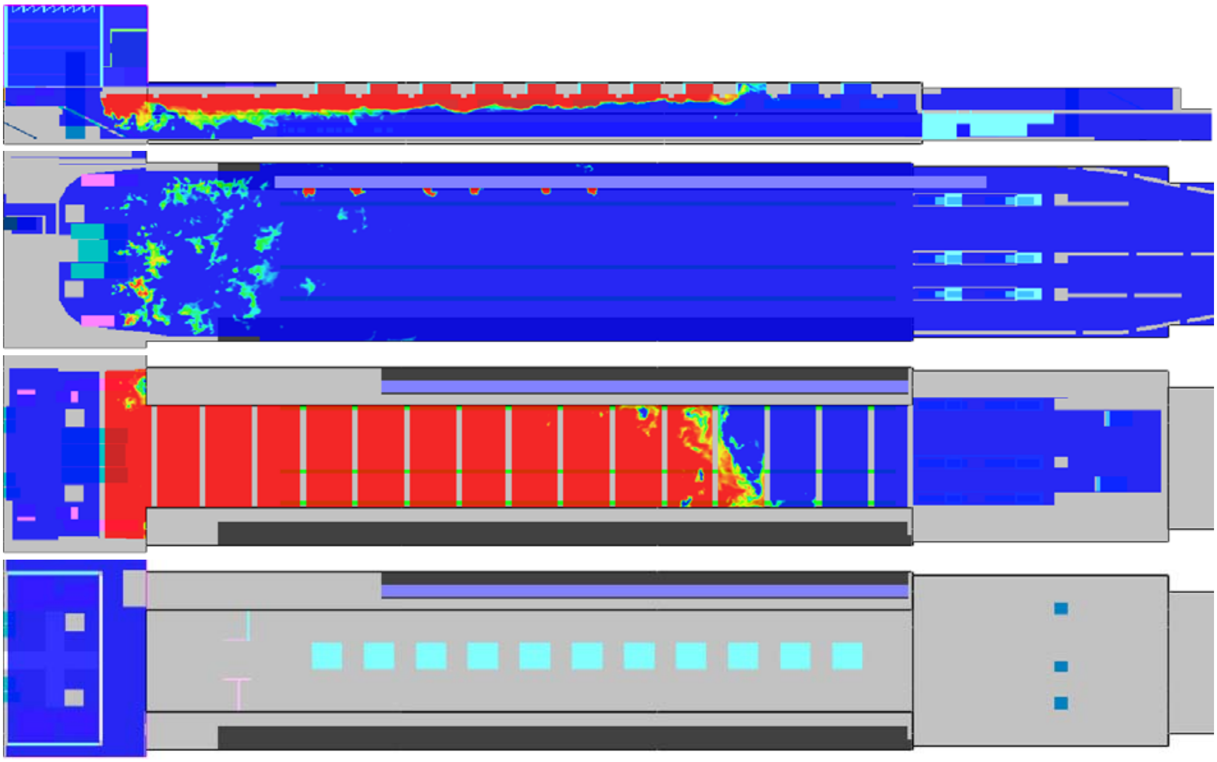


CO

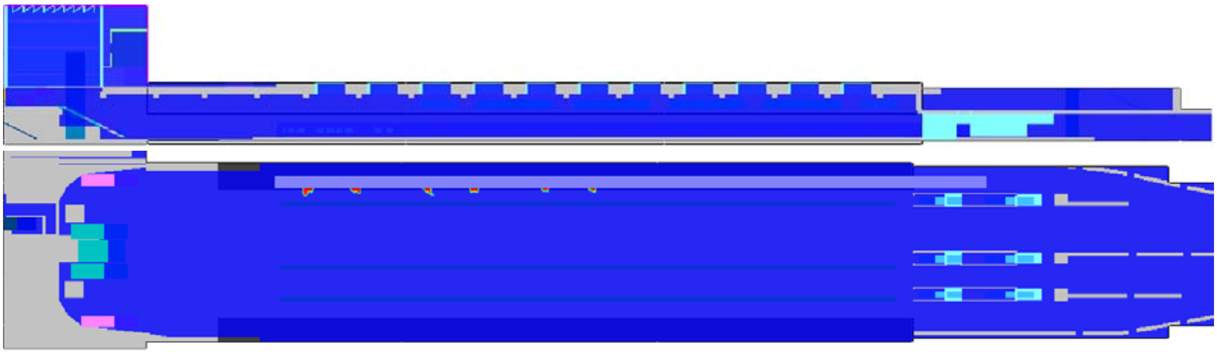


Fire Scenario 7E - Time = 480 seconds

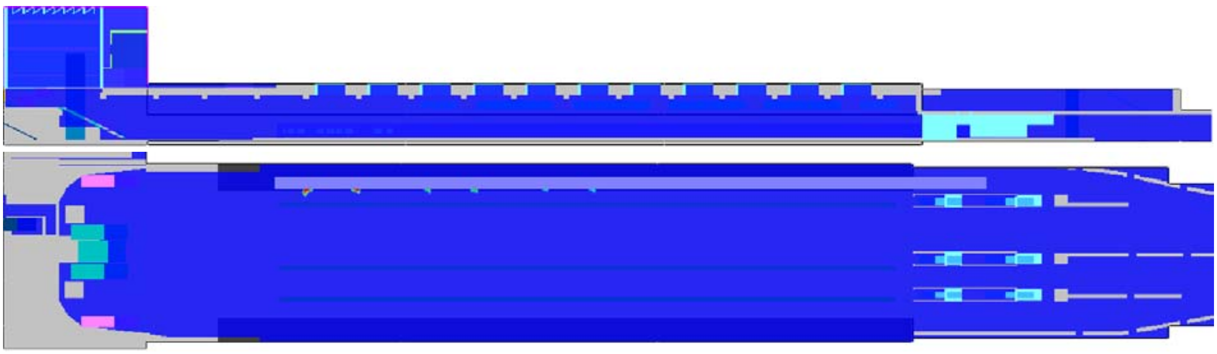
Visibility



Temperature

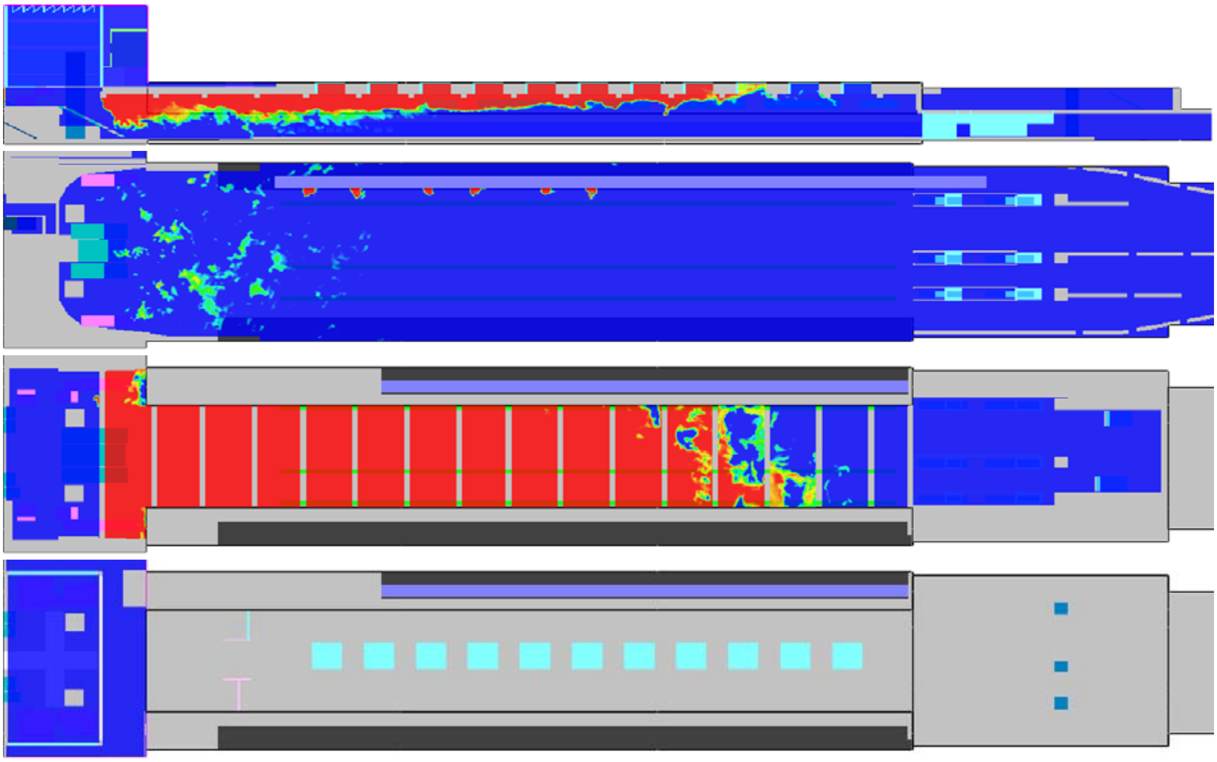


CO

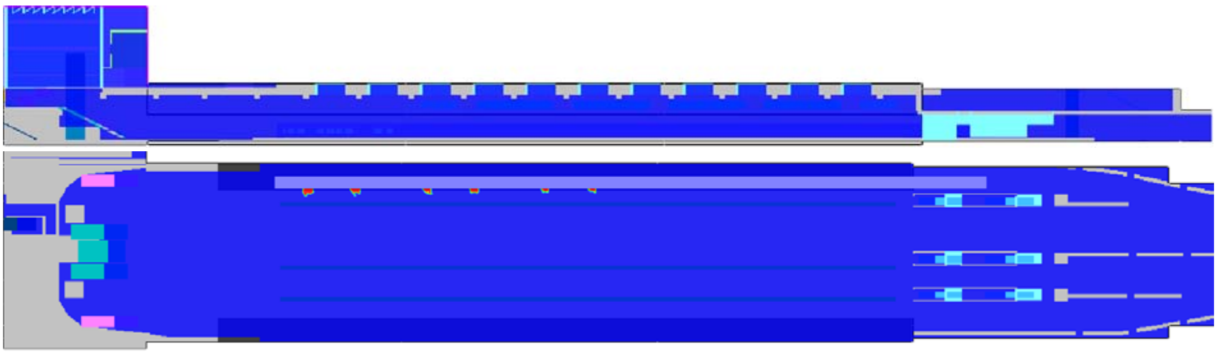


Fire Scenario 7E - Time = 600 seconds

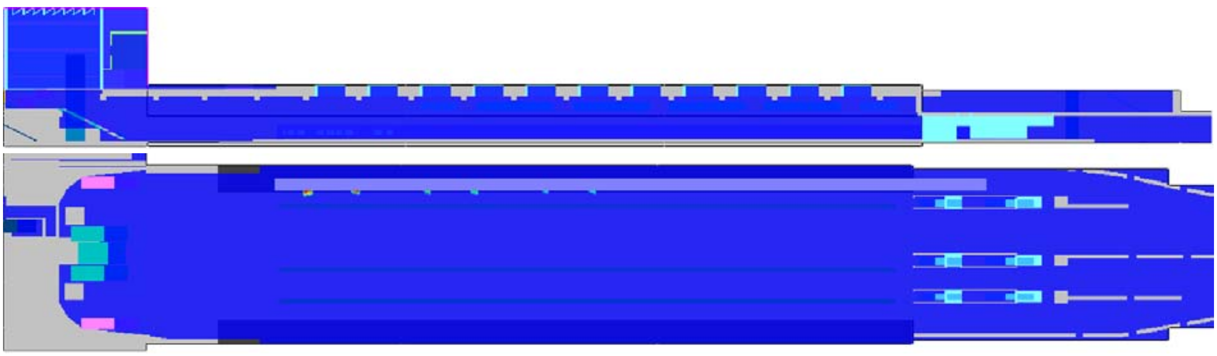
Visibility



Temperature

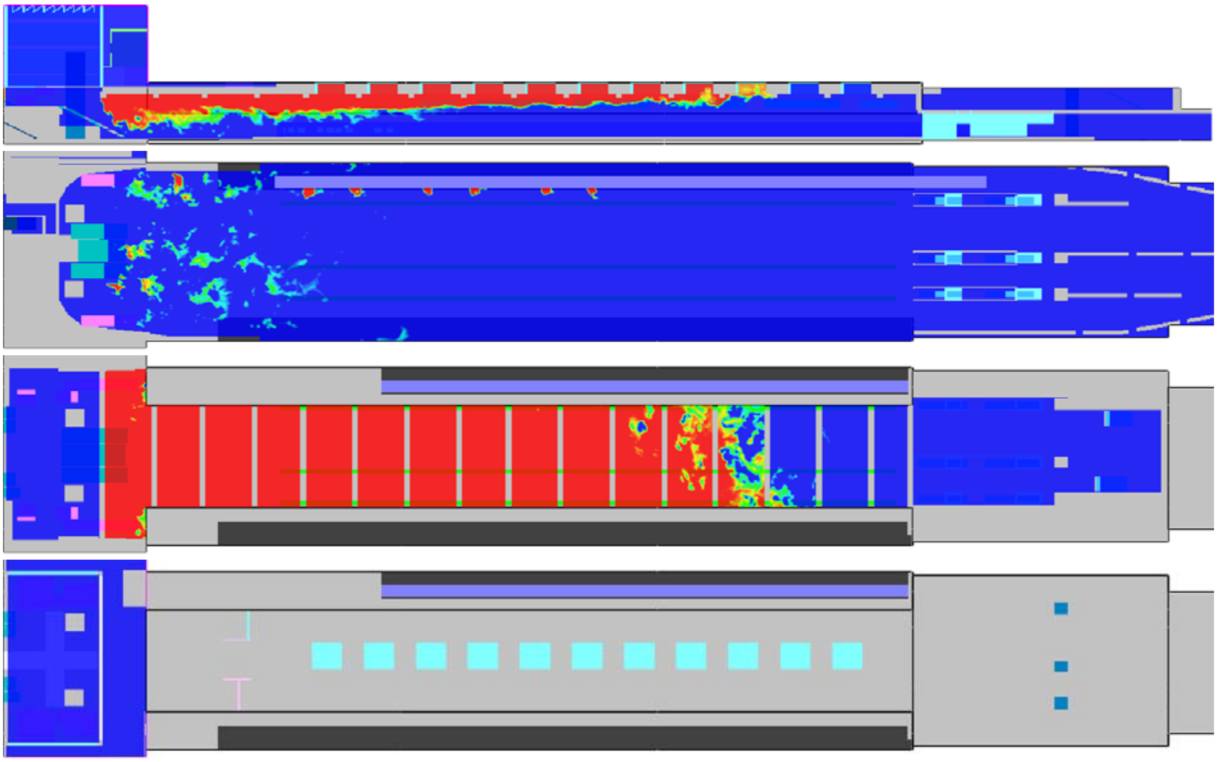


CO

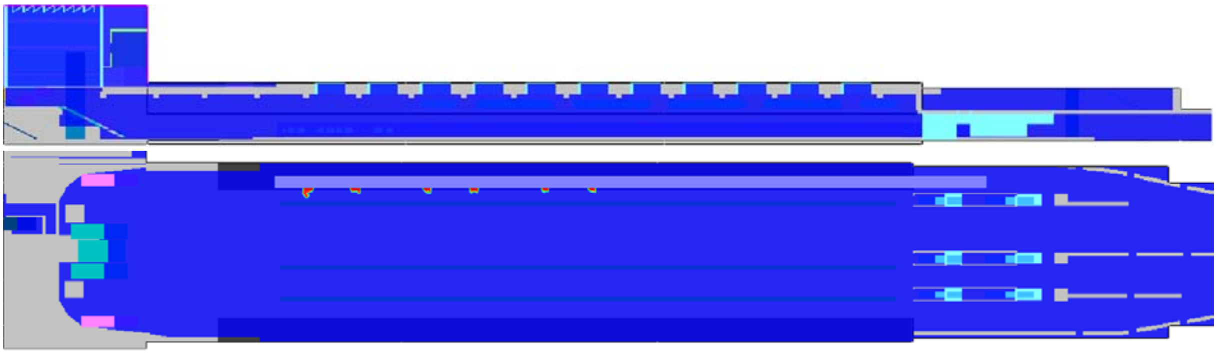


Fire Scenario 7E - Time = 660 seconds

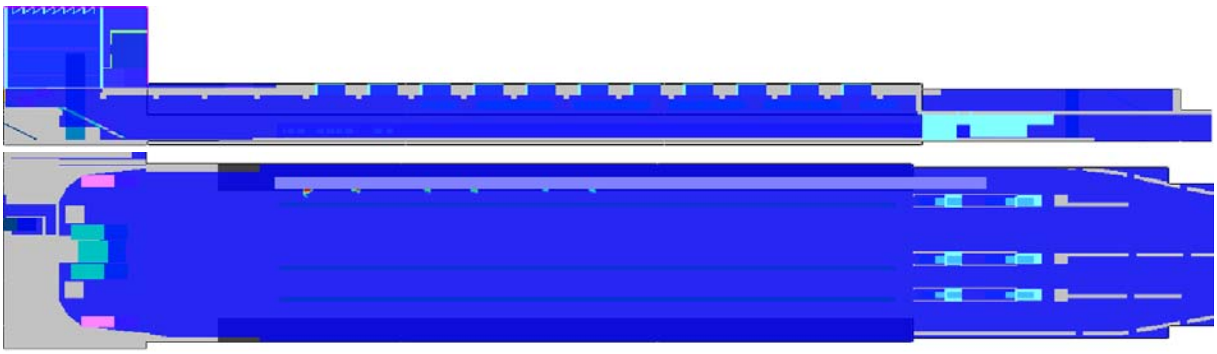
Visibility

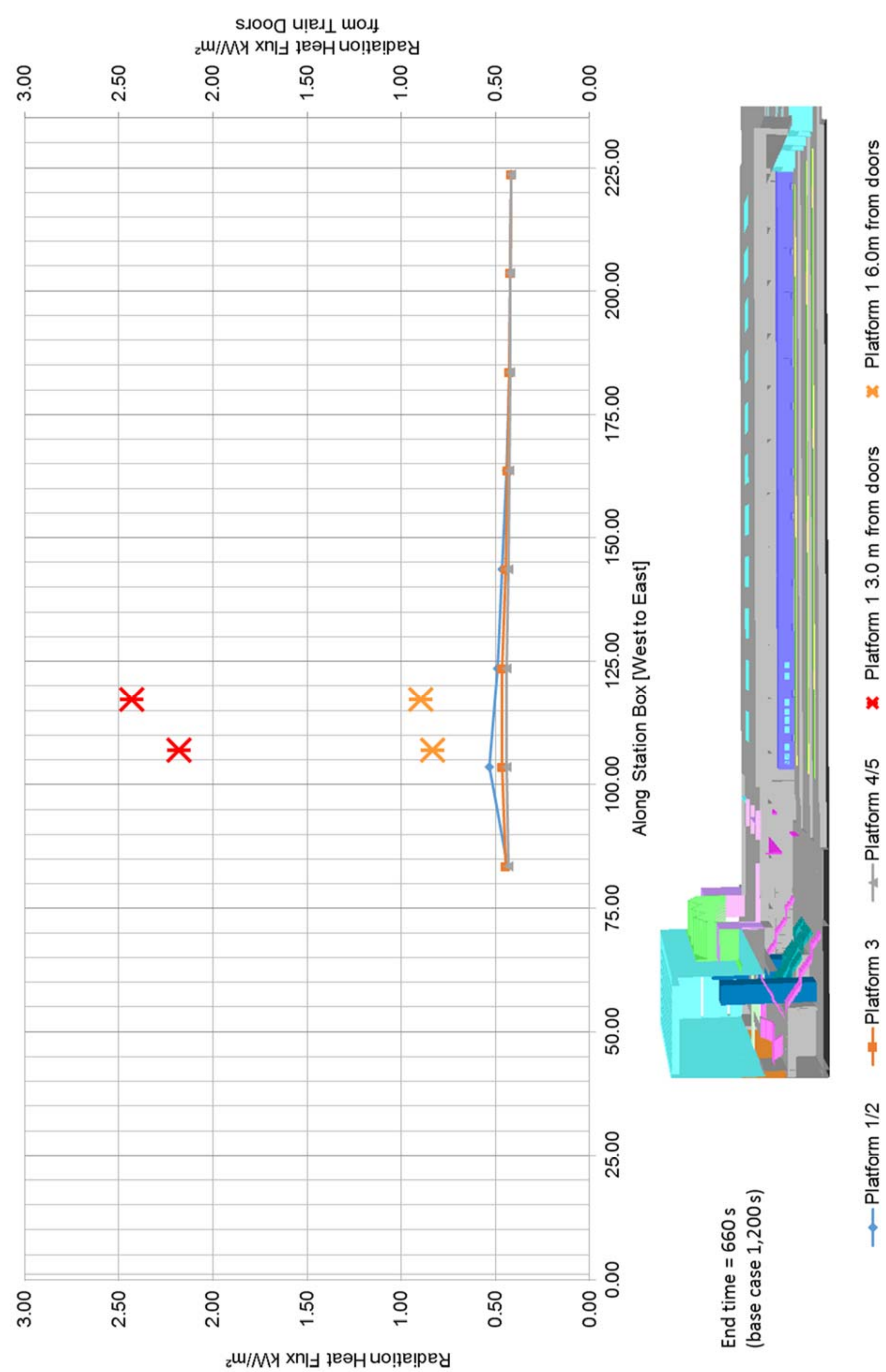


Temperature



CO




Radiation Heat Flux kW/m²
Radiation Heat Flux kW/m² from Train Doors
0.00
0.50
1.00
1.50
2.00
2.50
3.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
Along Station Box [West to East]
End time = 660 s
(base case 1,200 s)
Platform 1/2
Platform 3
Platform 4/5
Platform 1 3.0 m from doors
Platform 1 6.0m from doors

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Appendix I
Permanent Works FDS Results

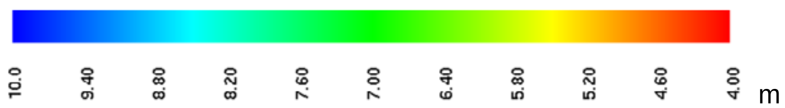
Permanent Works Fire Models

Fire Scenario	Run ID	Location	Design Fires	Active Fire Systems	Case
1P	17b	Track 1 Carriage 1 (highest challenge location)	Fast t^2 4 MW	Fully functioning	Base Case
3P	18	Track 3, Carriage 1 (highest challenge east end)	Fast t^2 4 MW	Fully functioning	Base Case
5P	21	Track 1 Carriage 1	Medium t^2 10 MW	Fully functioning	Sensitivity
6P	33	Track 1 Carriage 1	Fast t^2 4 MW	50% mechanical exhaust	Redundancy
7P	26	Track 1 Carriage 1	Fast t^2 4 MW	Smoke curtain failure	Redundancy

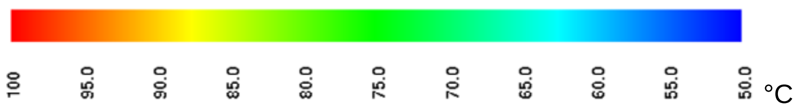
Legend

<u>Data bounds</u>

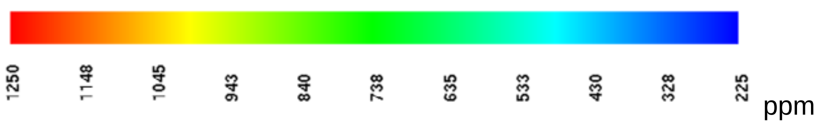
Visibility



Temperature

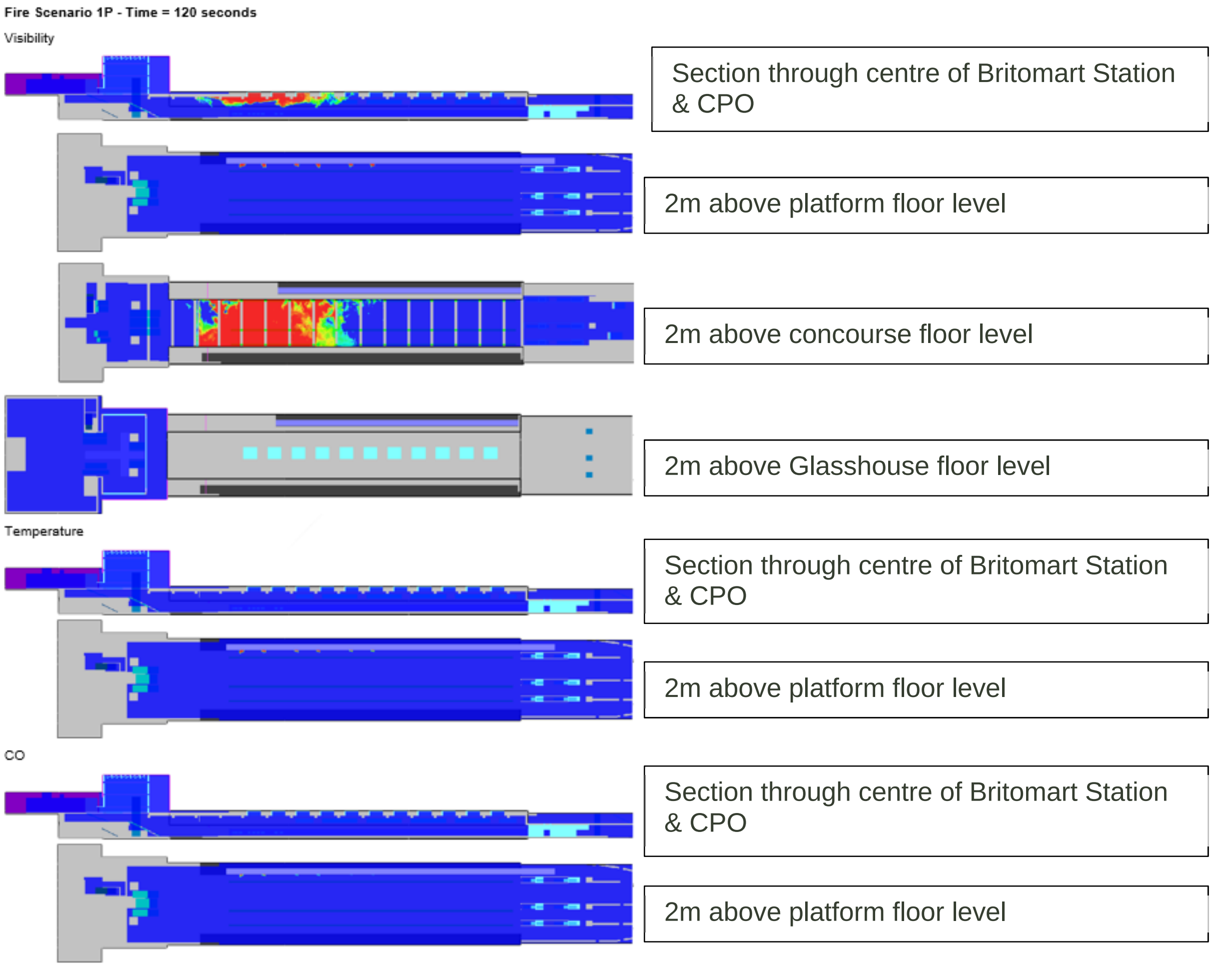


CO Concentration

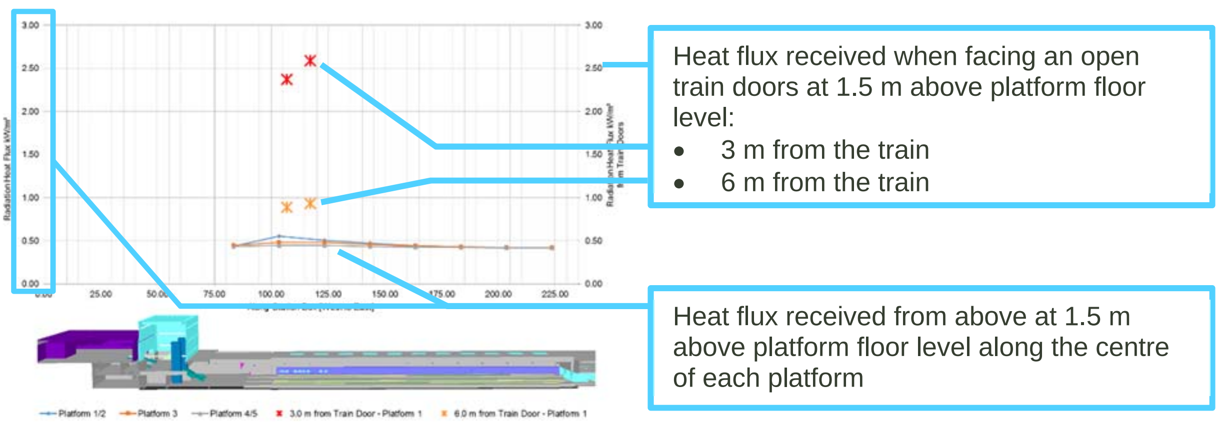


Views

The following views have been used in this report to depict the quantitative results for each simulation listed above.

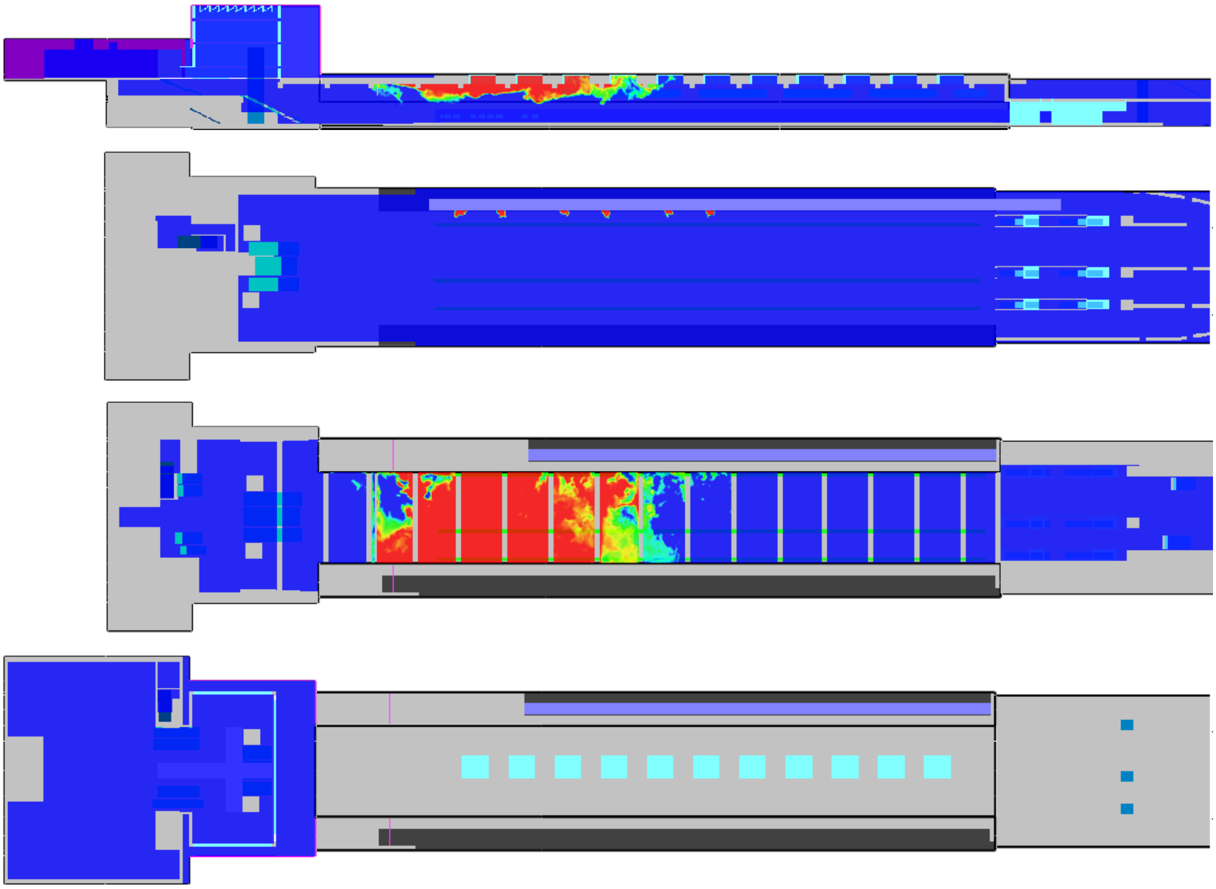


The following graph shows an example of the heat fluxes as measured by devices in the simulations to assess performance relative to the acceptance criteria.

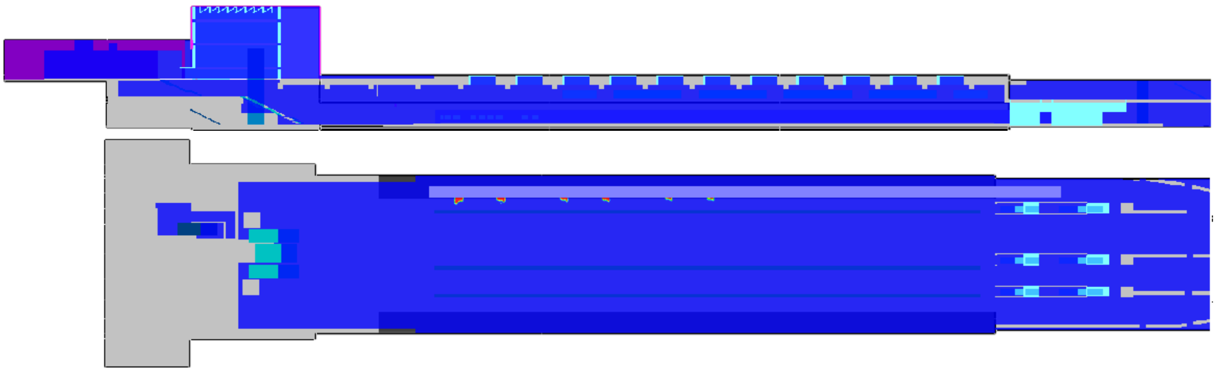


Fire Scenario 1P - Time = 120 seconds

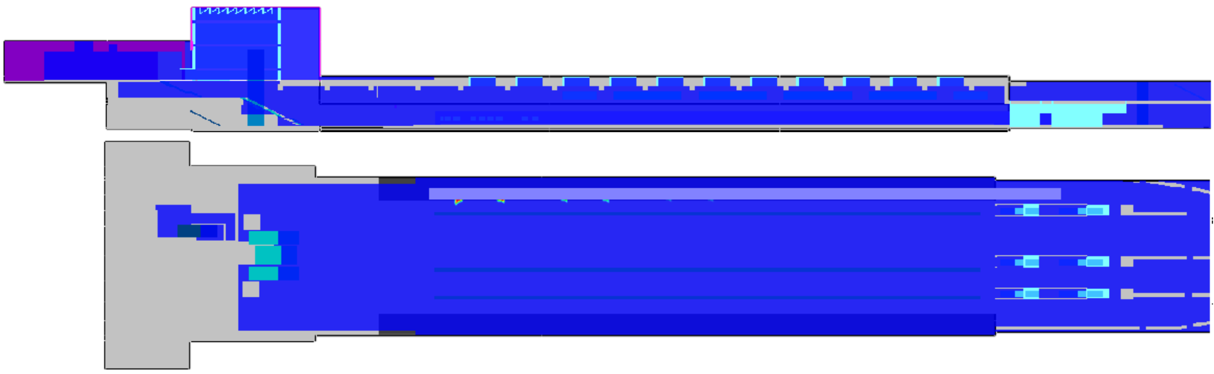
Visibility



Temperature

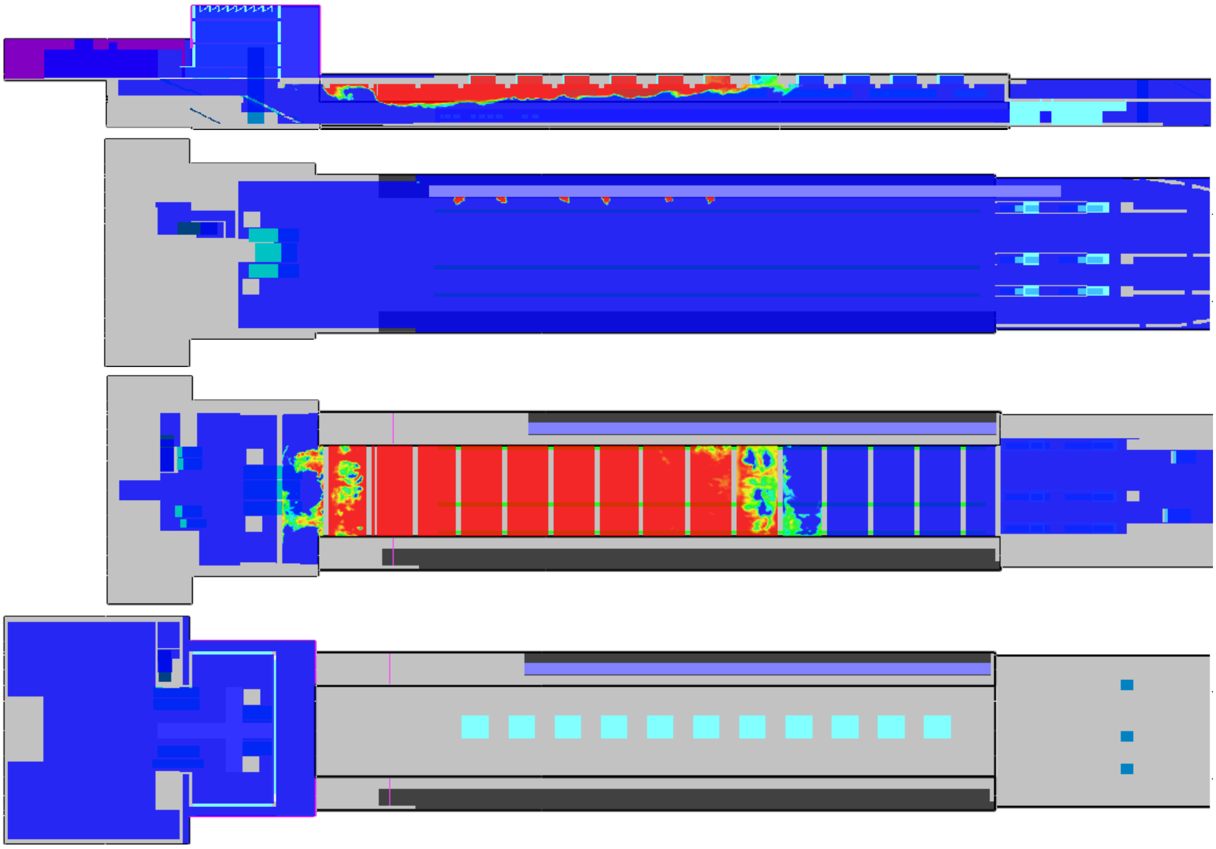


CO

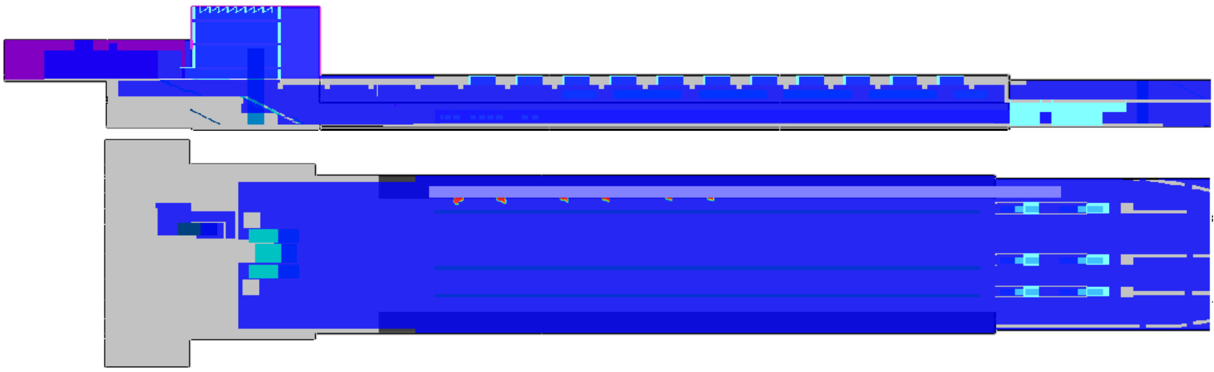


Fire Scenario 1P - Time = 240 seconds

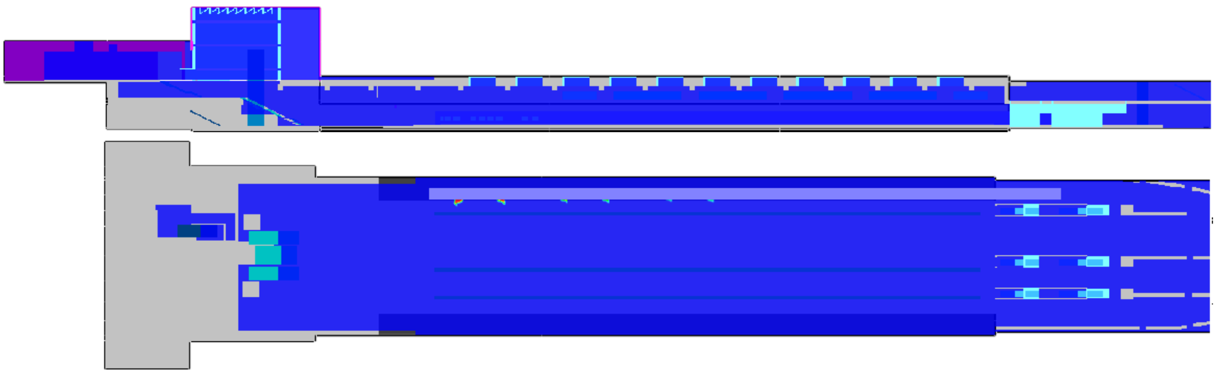
Visibility



Temperature

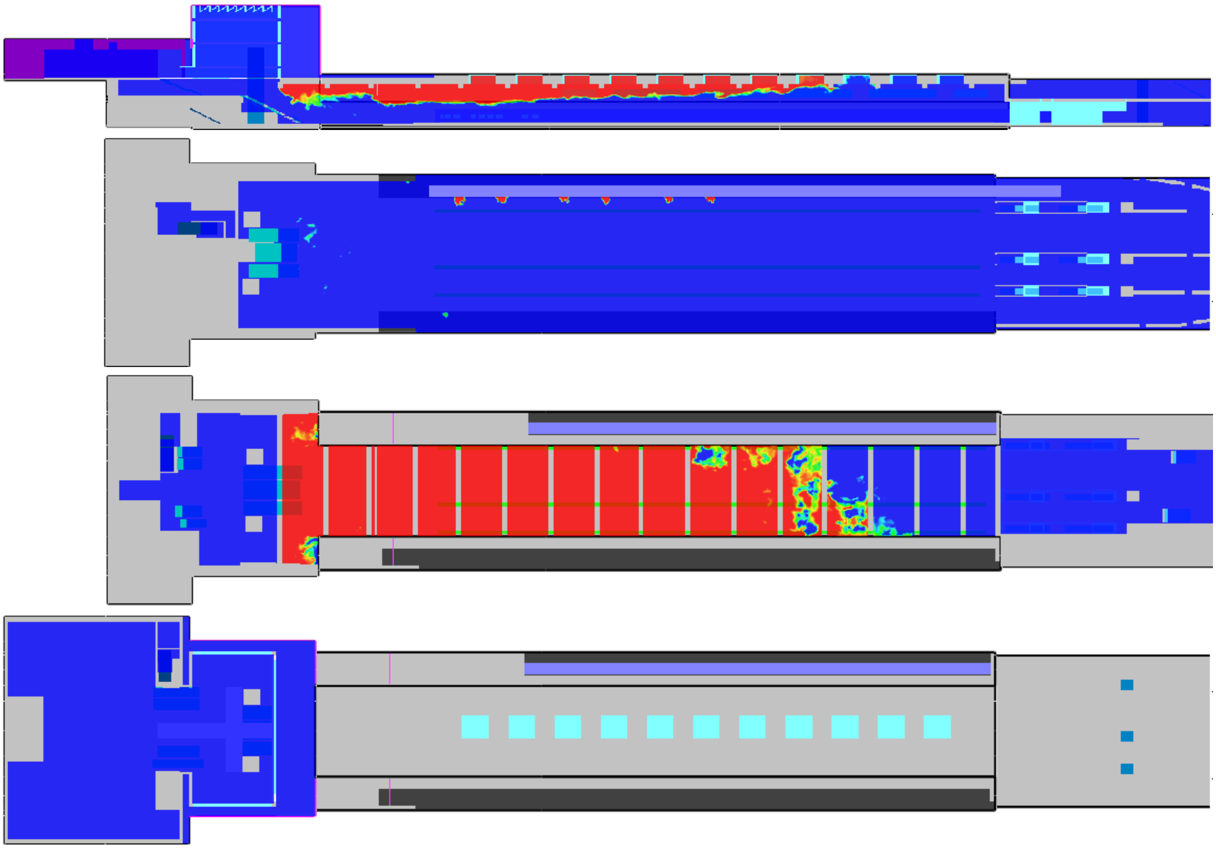


CO

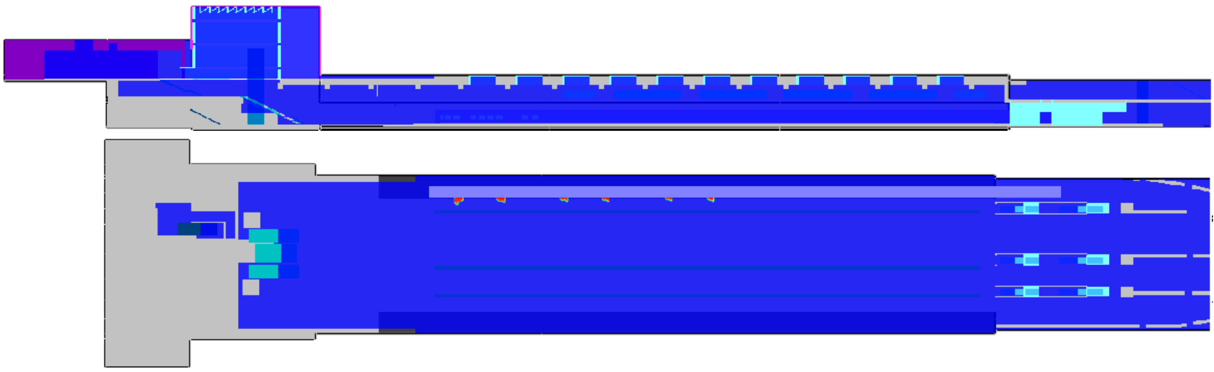


Fire Scenario 1P - Time = 360 seconds

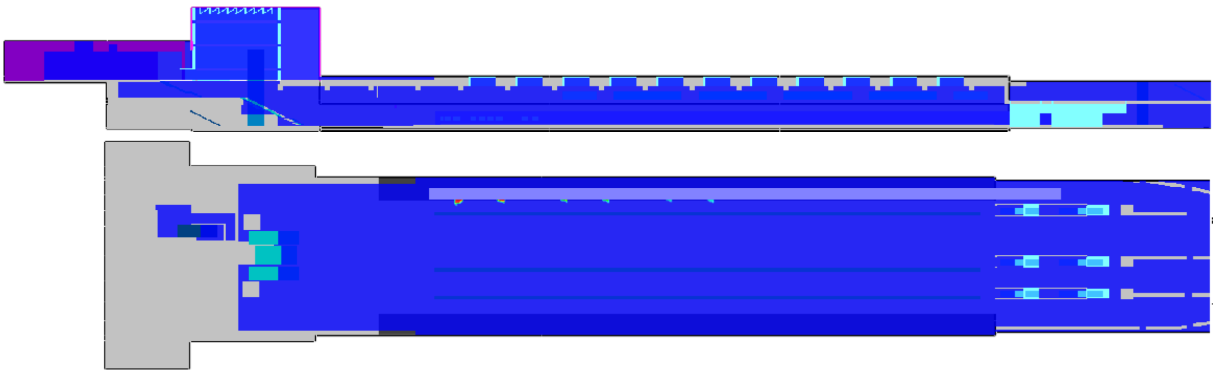
Visibility



Temperature

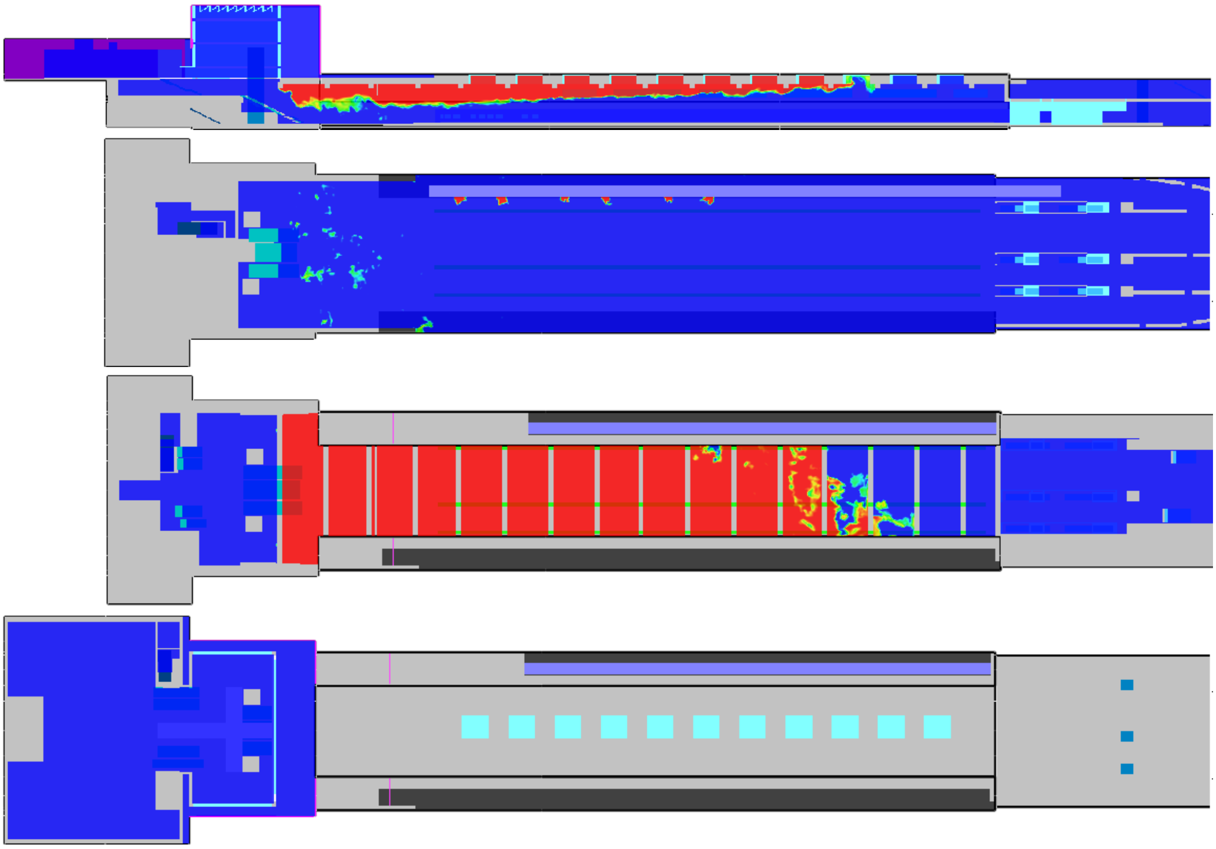


CO

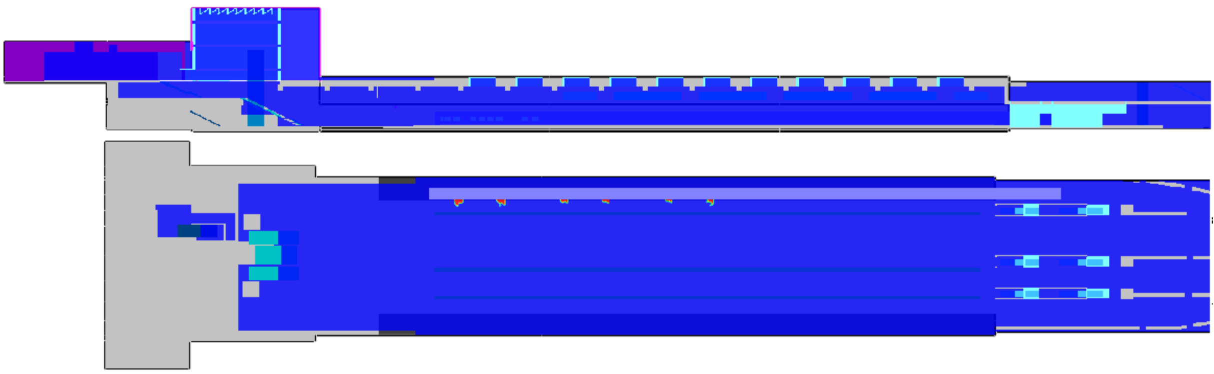


Fire Scenario 1P - Time = 480 seconds

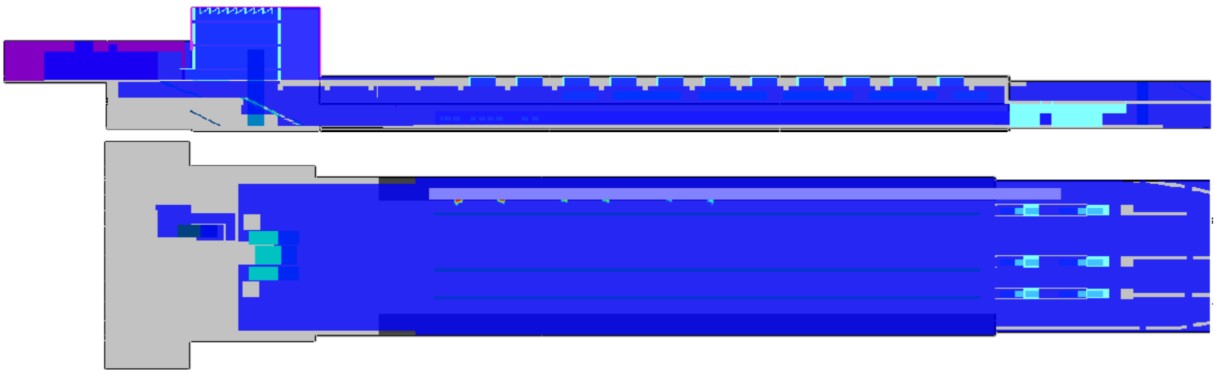
Visibility



Temperature

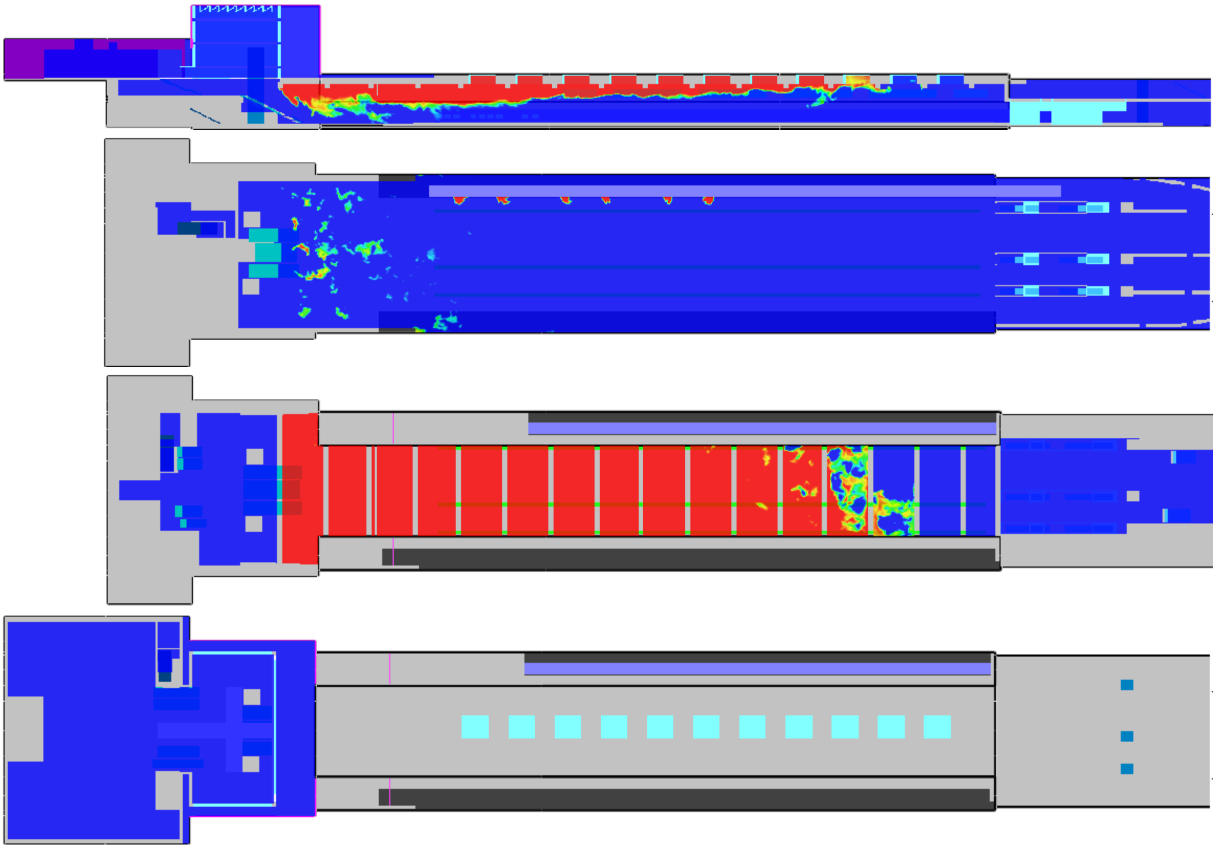


CO

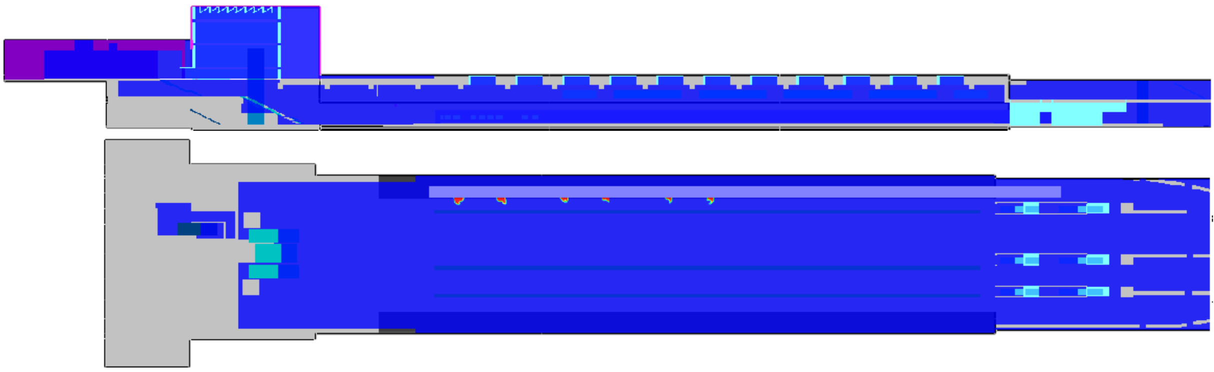


Fire Scenario 1P - Time = 600 seconds

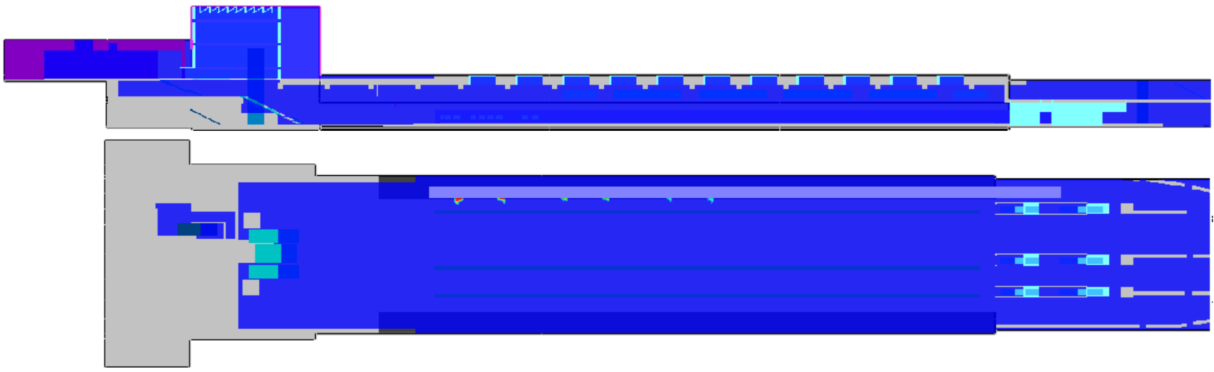
Visibility



Temperature

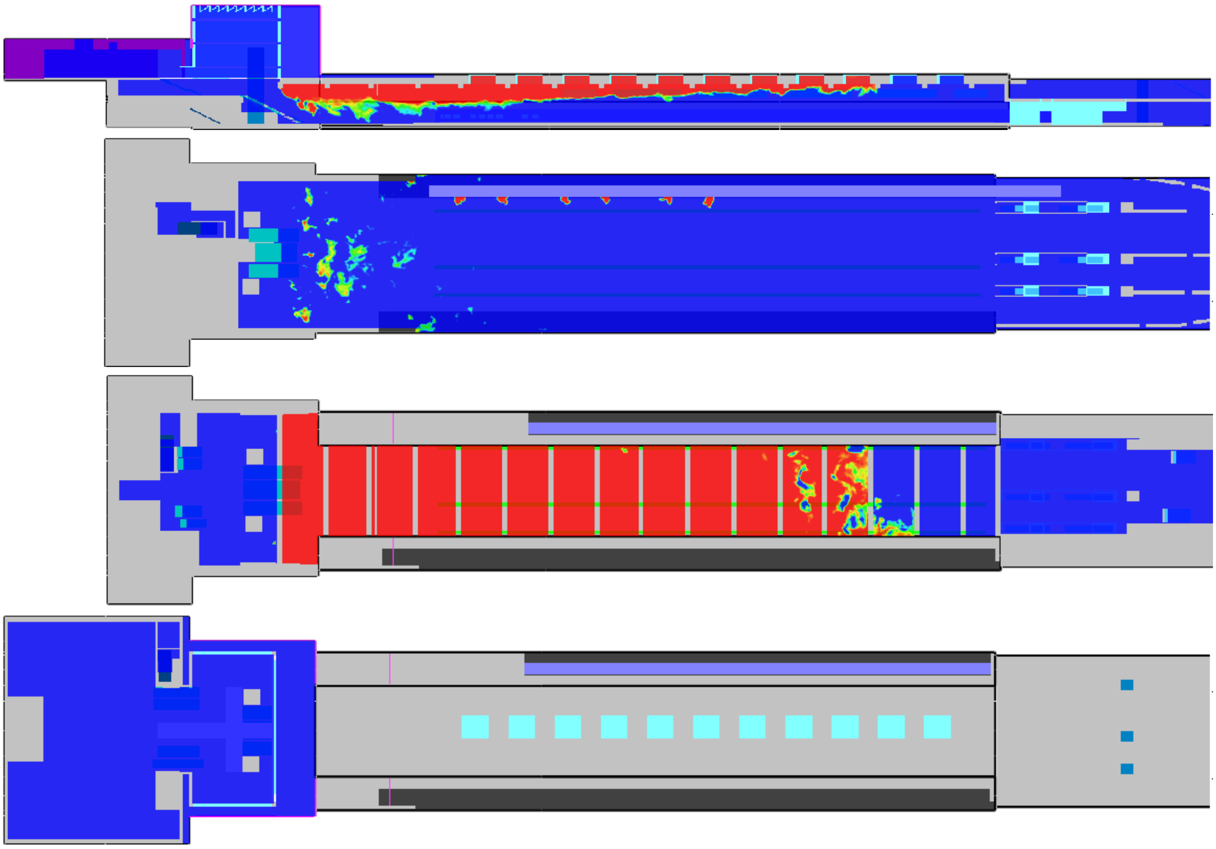


CO

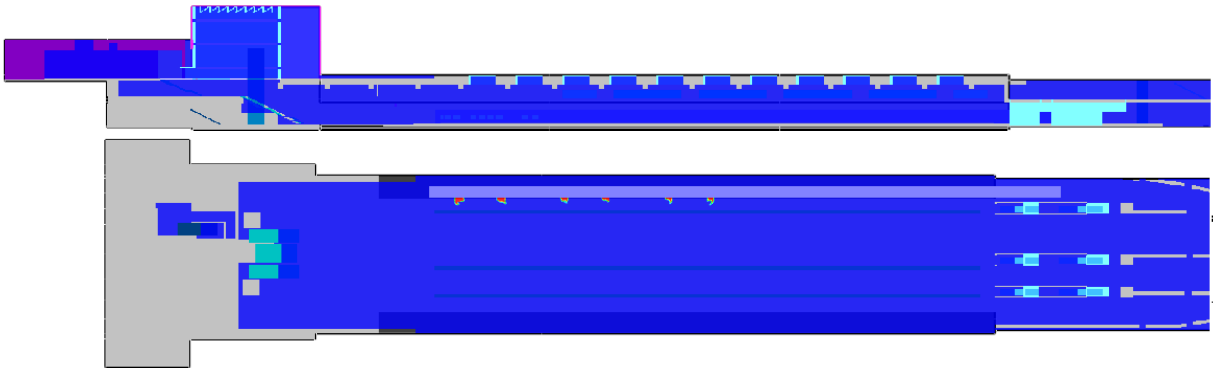


Fire Scenario 1P - Time = 720 seconds

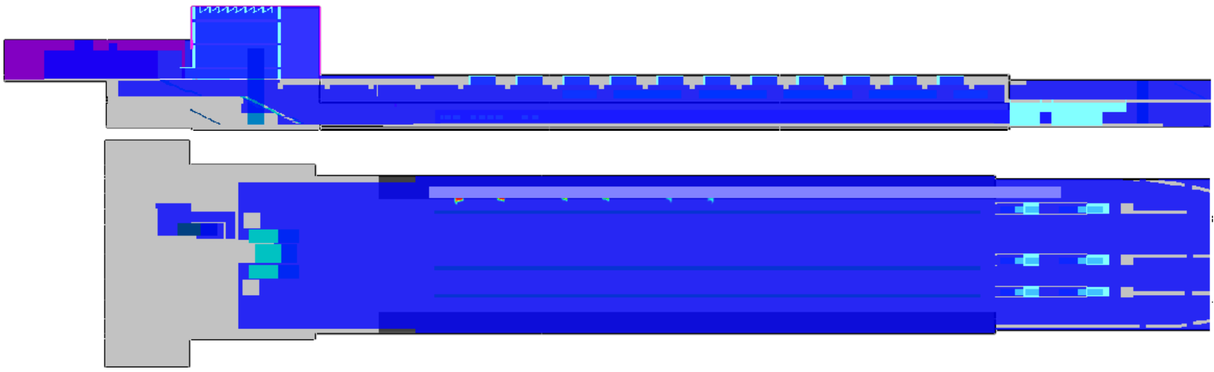
Visibility



Temperature

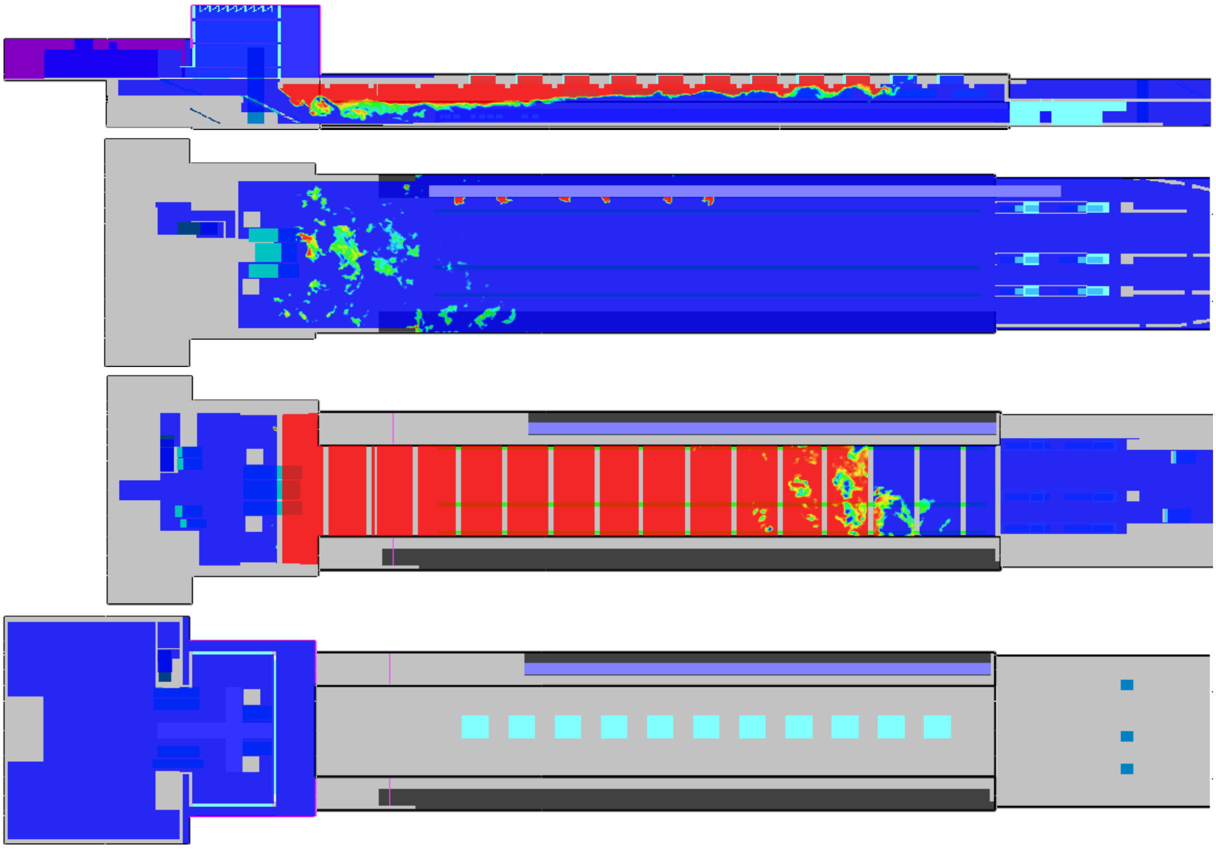


CO

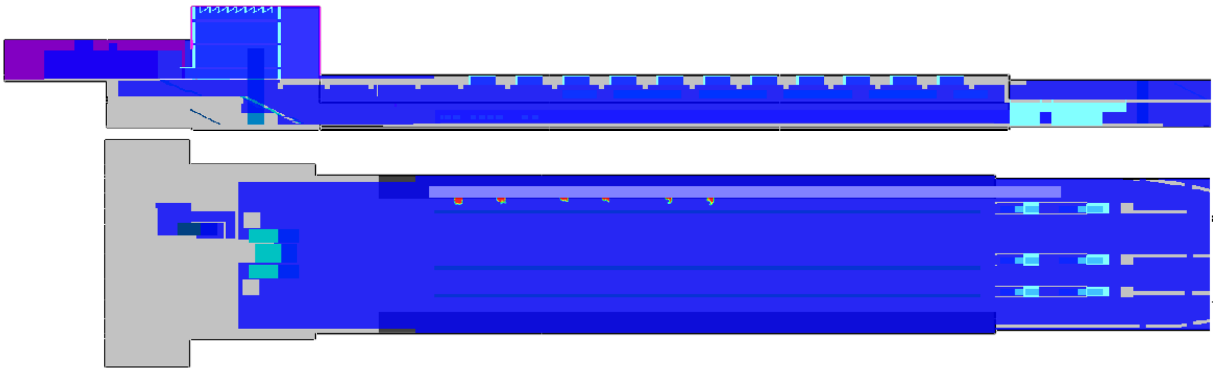


Fire Scenario 1P - Time = 840 seconds

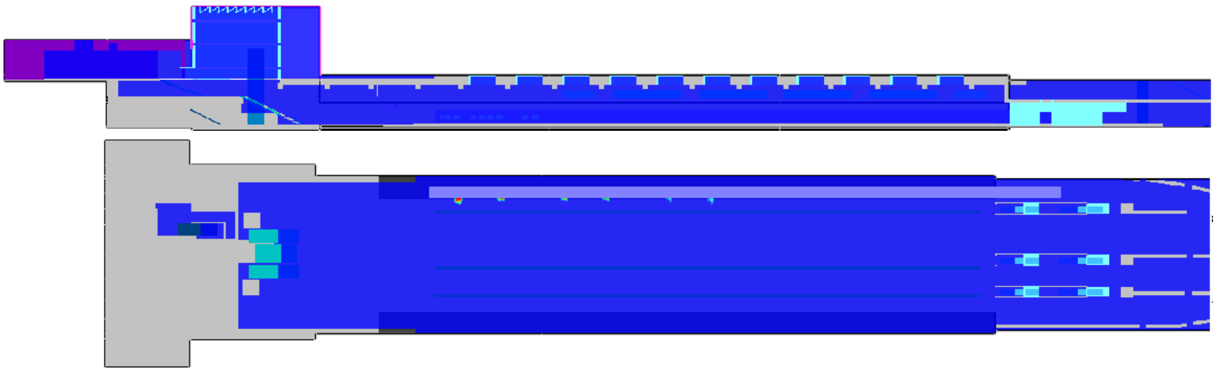
Visibility



Temperature

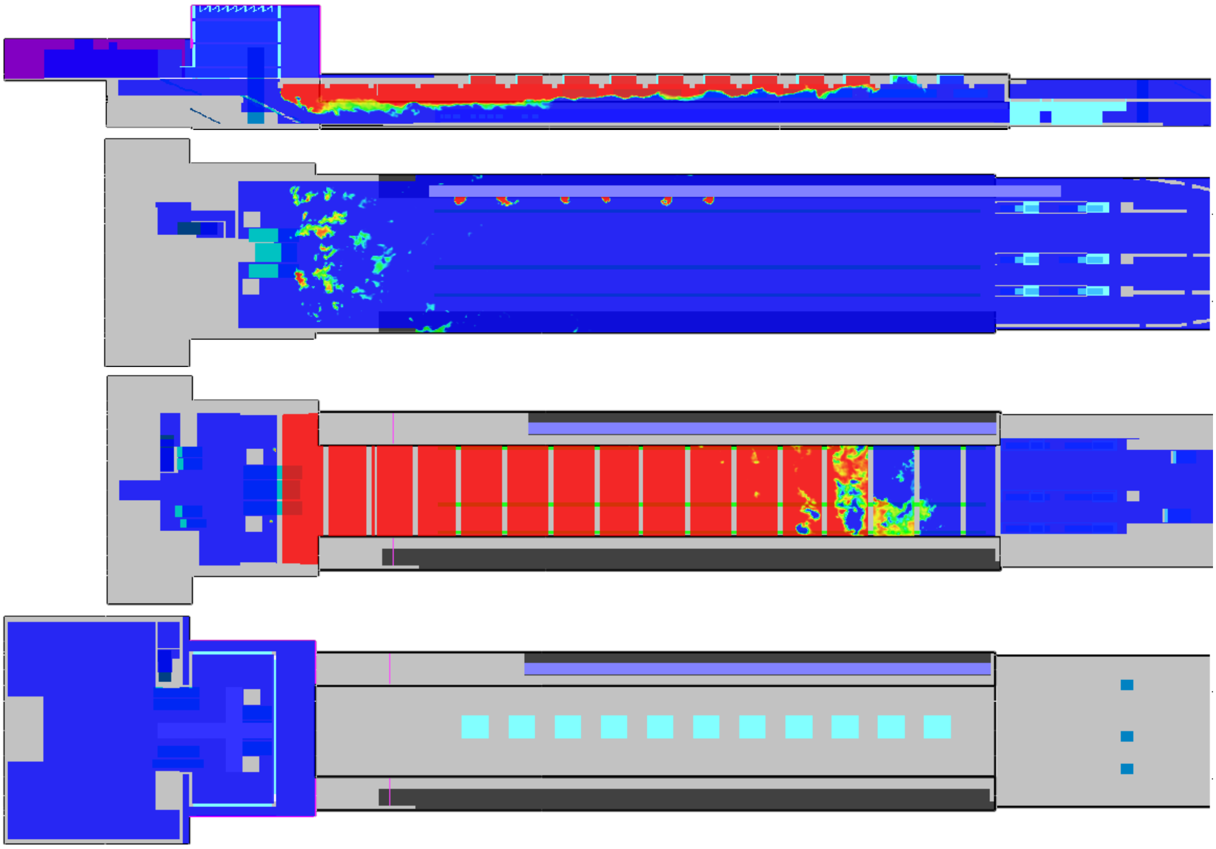


CO

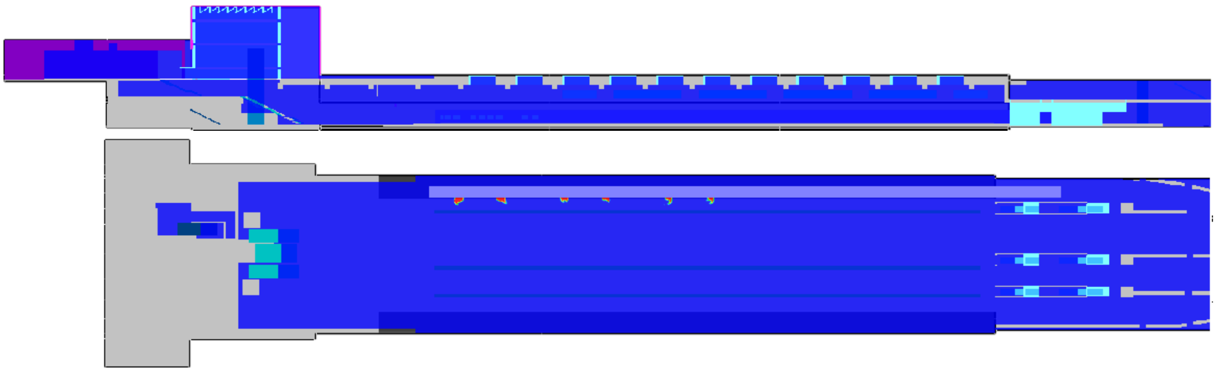


Fire Scenario 1P - Time = 960 seconds

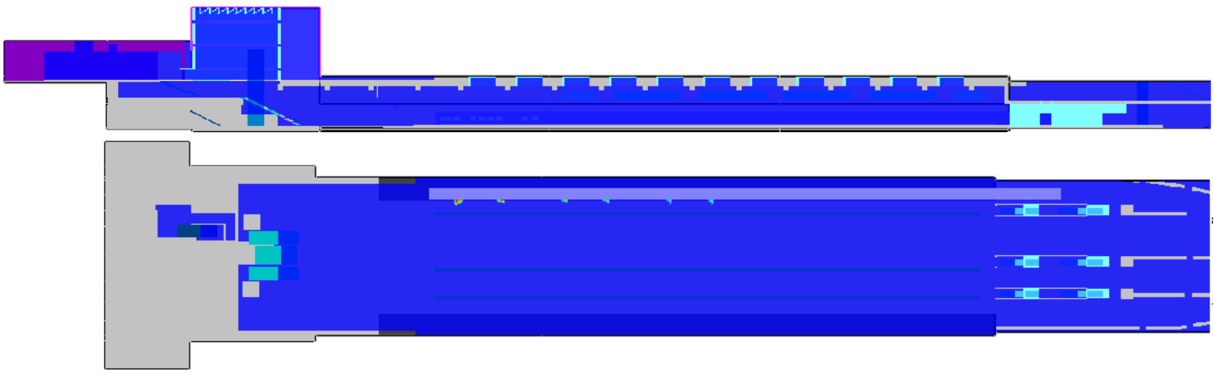
Visibility



Temperature

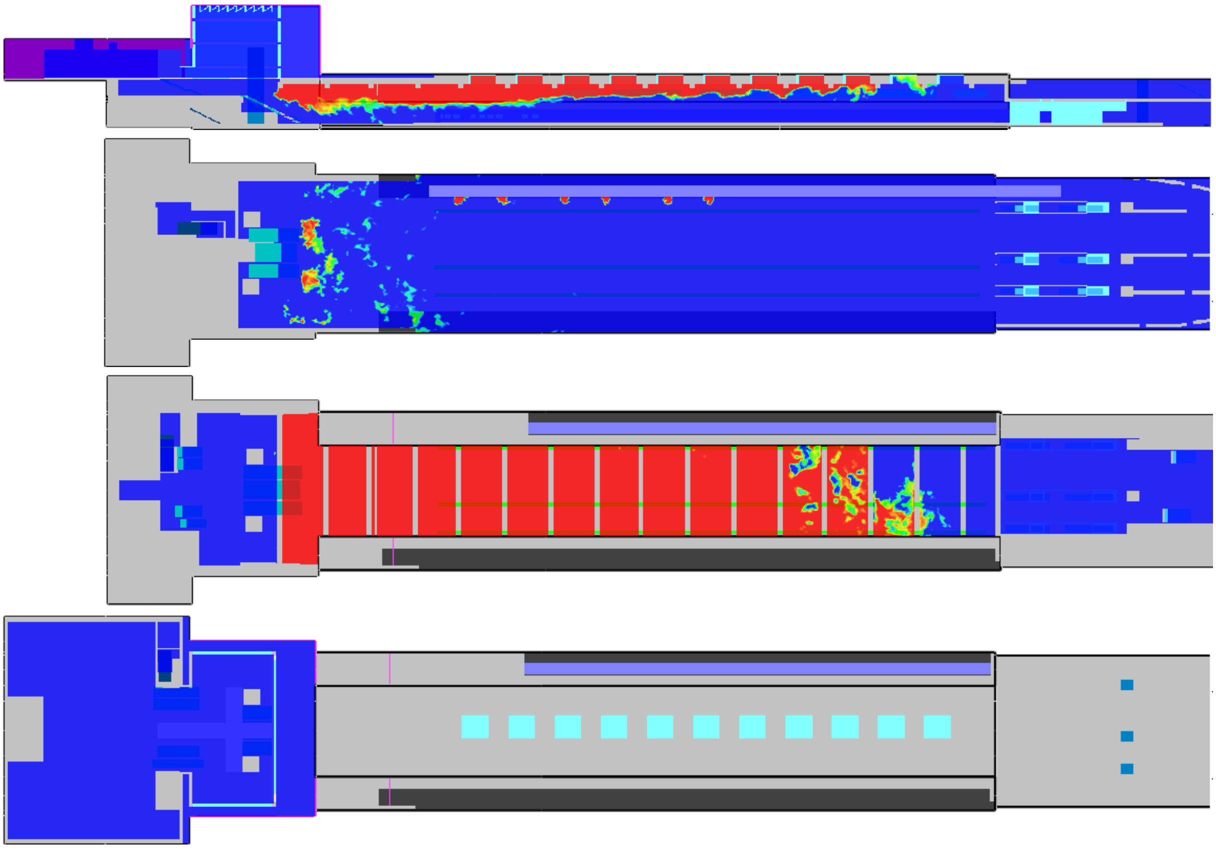


CO

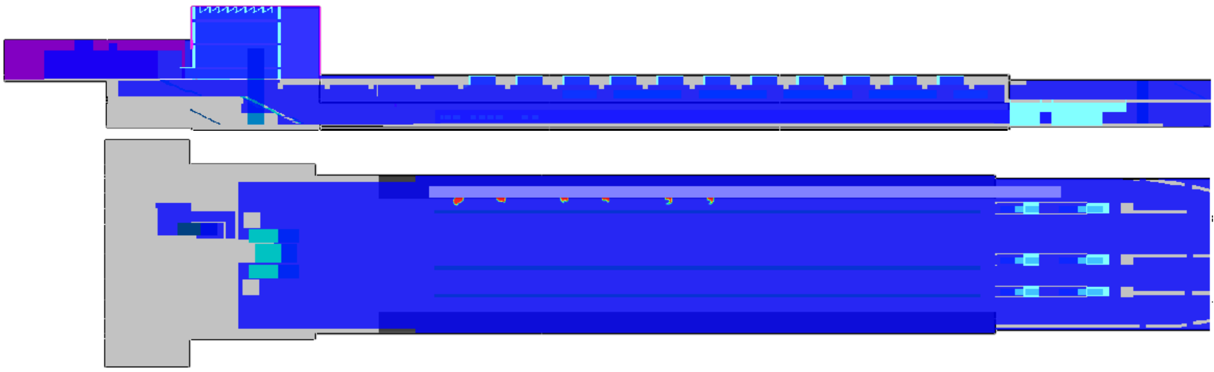


Fire Scenario 1P - Time = 1,200 seconds

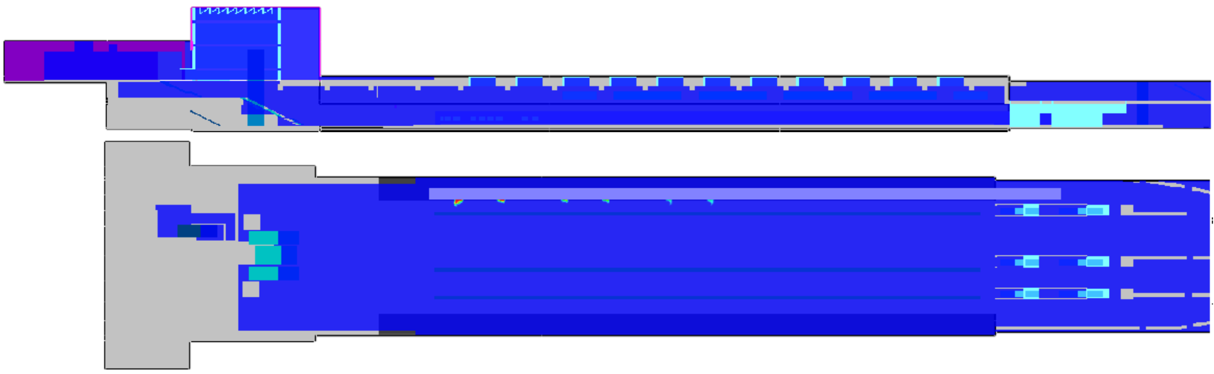
Visibility

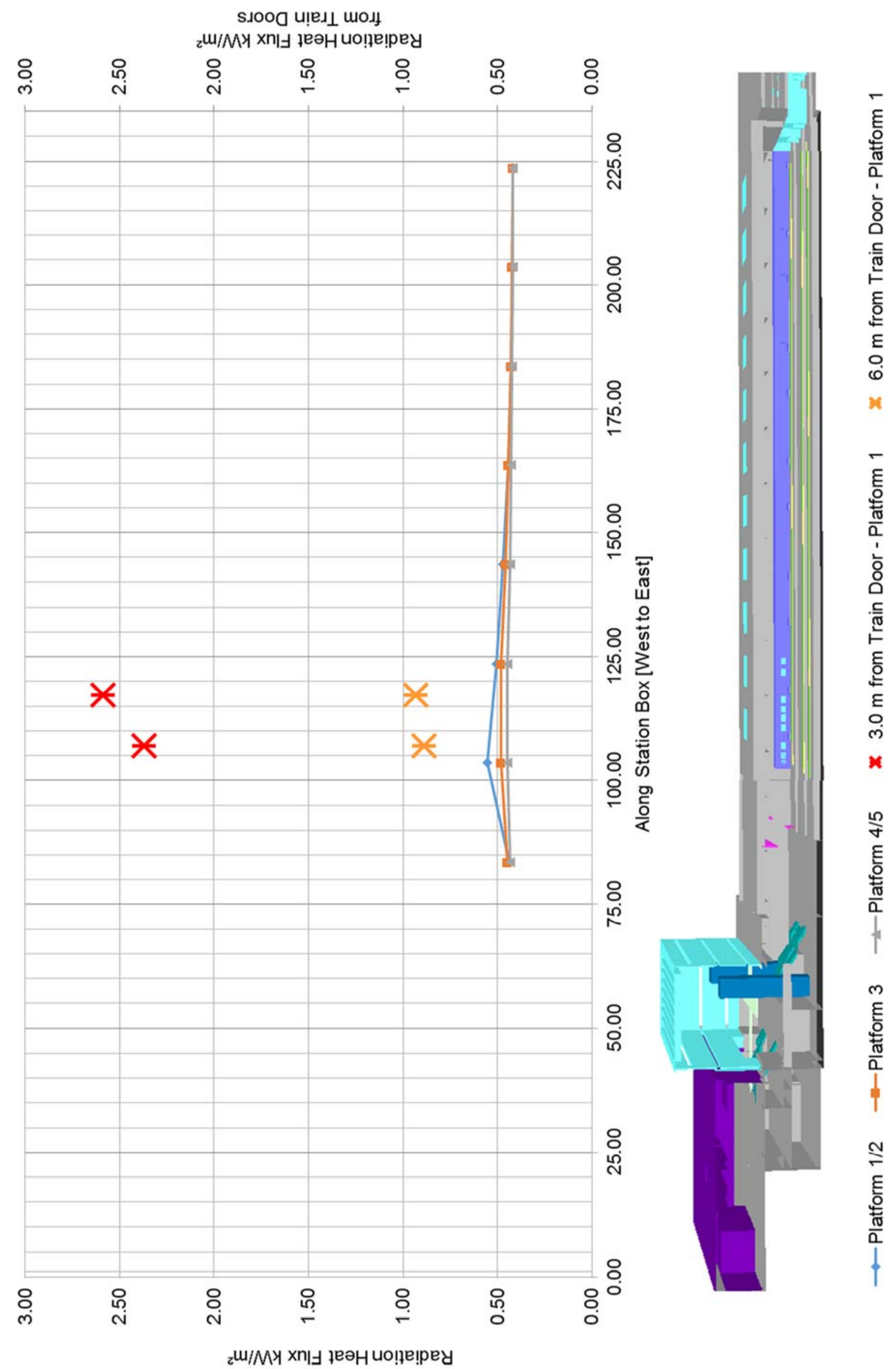


Temperature



CO

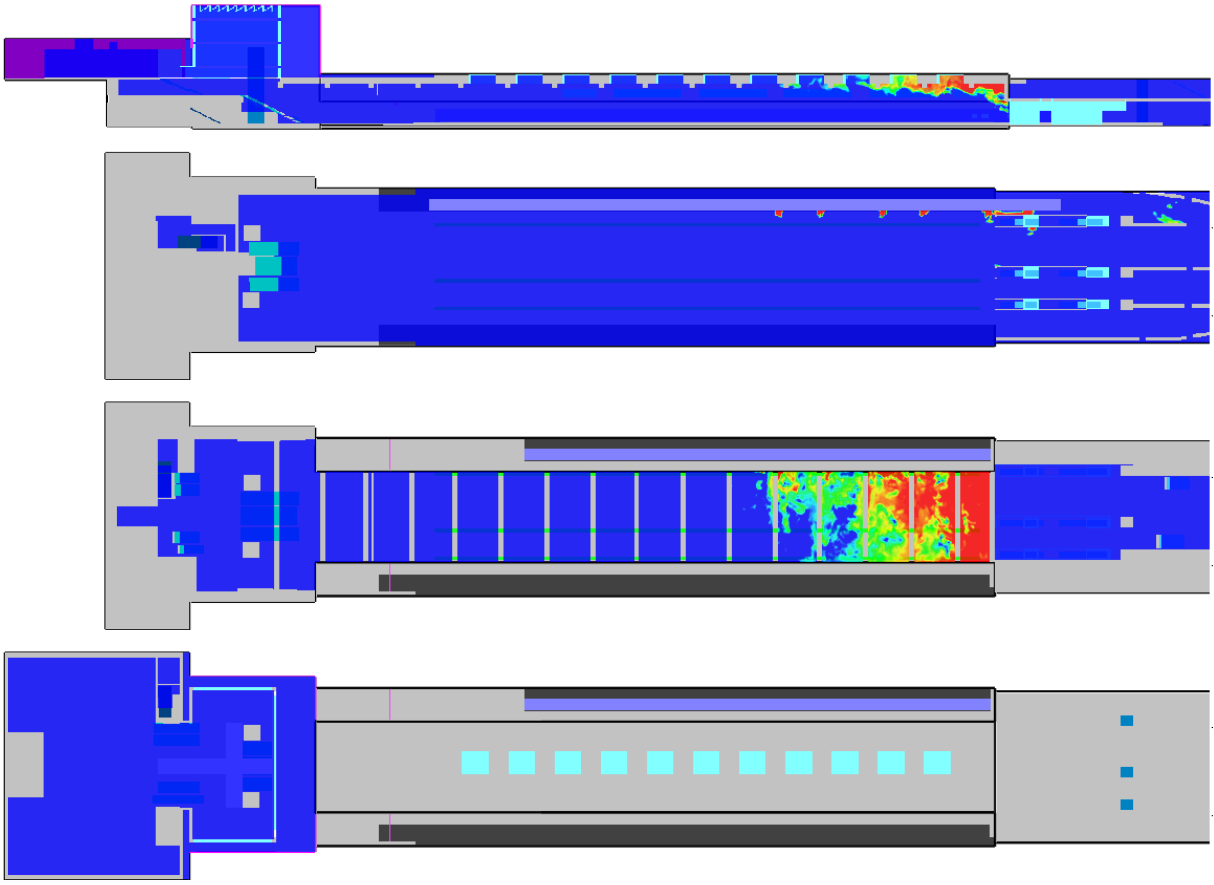




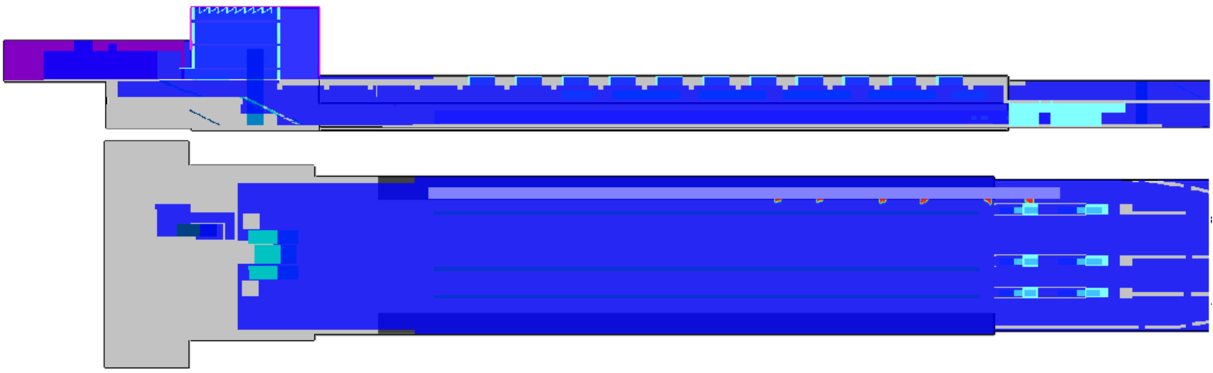
Radiation Heat Flux kW/m²
Radiation Heat Flux kW/m² from Train Doors
Along Station Box [West to East]
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Platform 1/2
Platform 3
Platform 4/5
3.0 m from Train Door - Platform 1
6.0 m from Train Door - Platform 1

Fire Scenario 3P - Time = 120 seconds

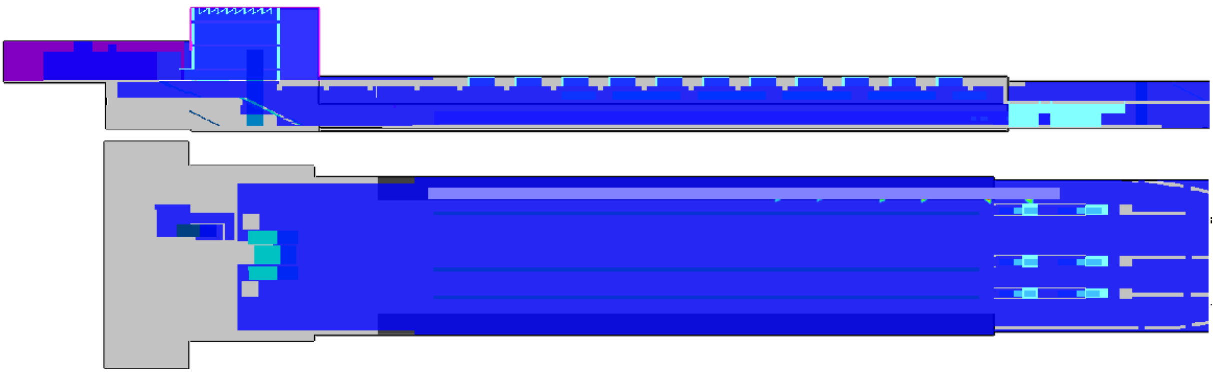
Visibility



Temperature

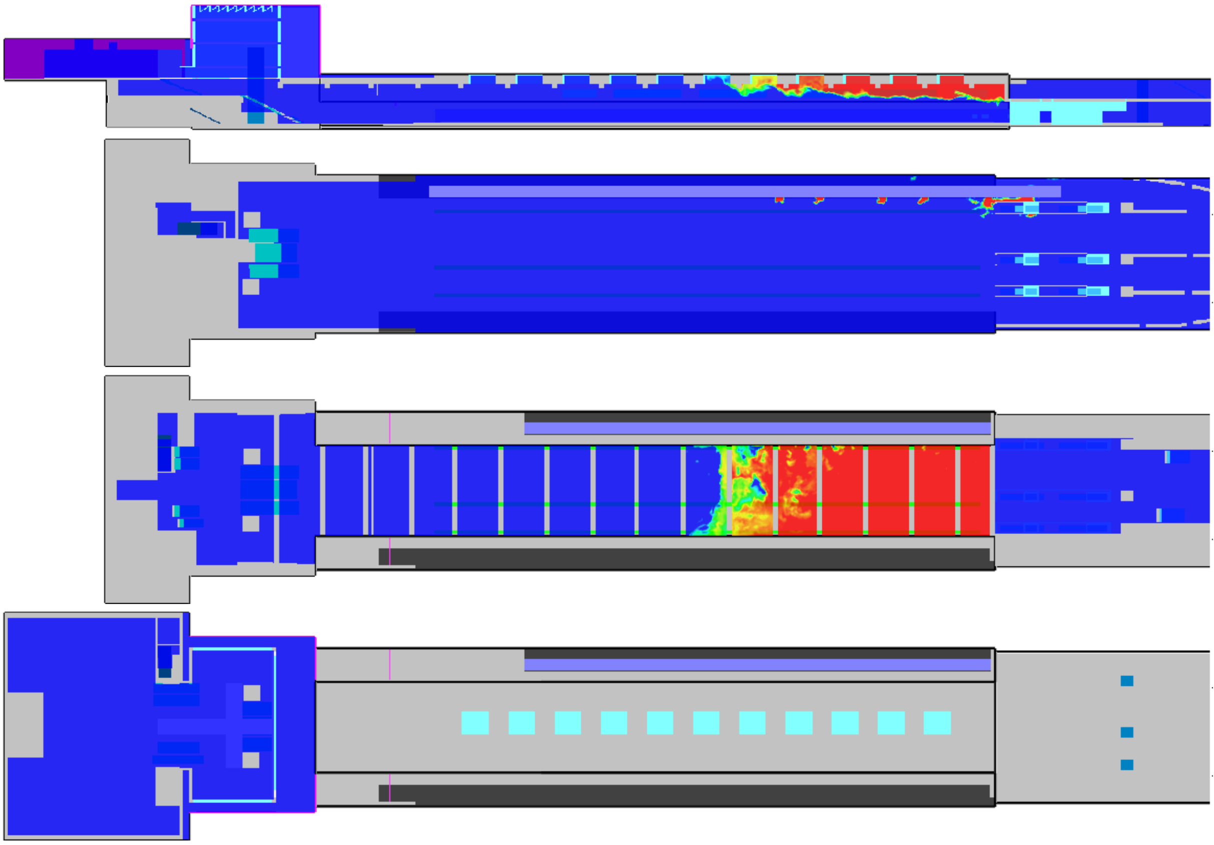


CO

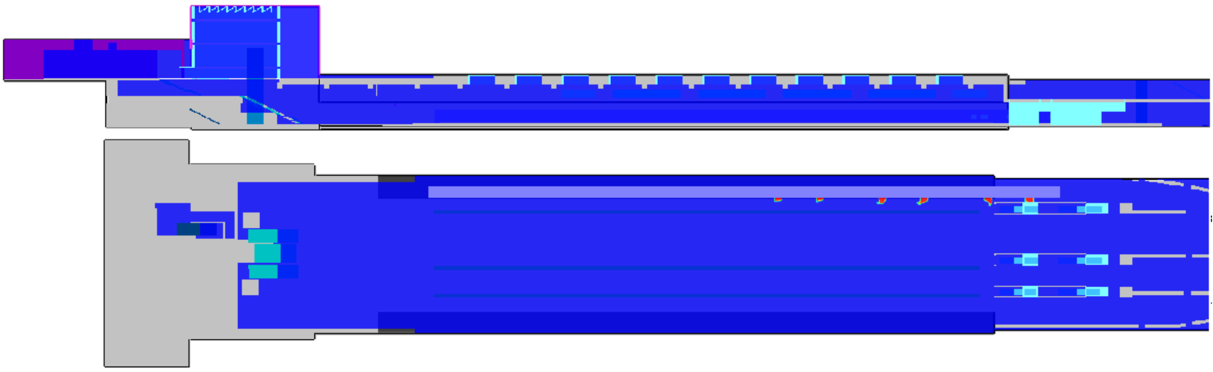


Fire Scenario 3P - Time = 240 seconds

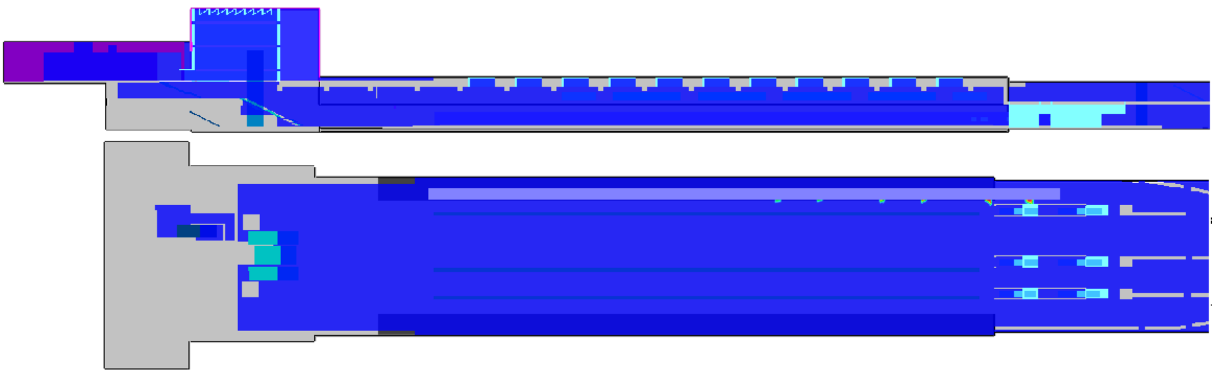
Visibility



Temperature

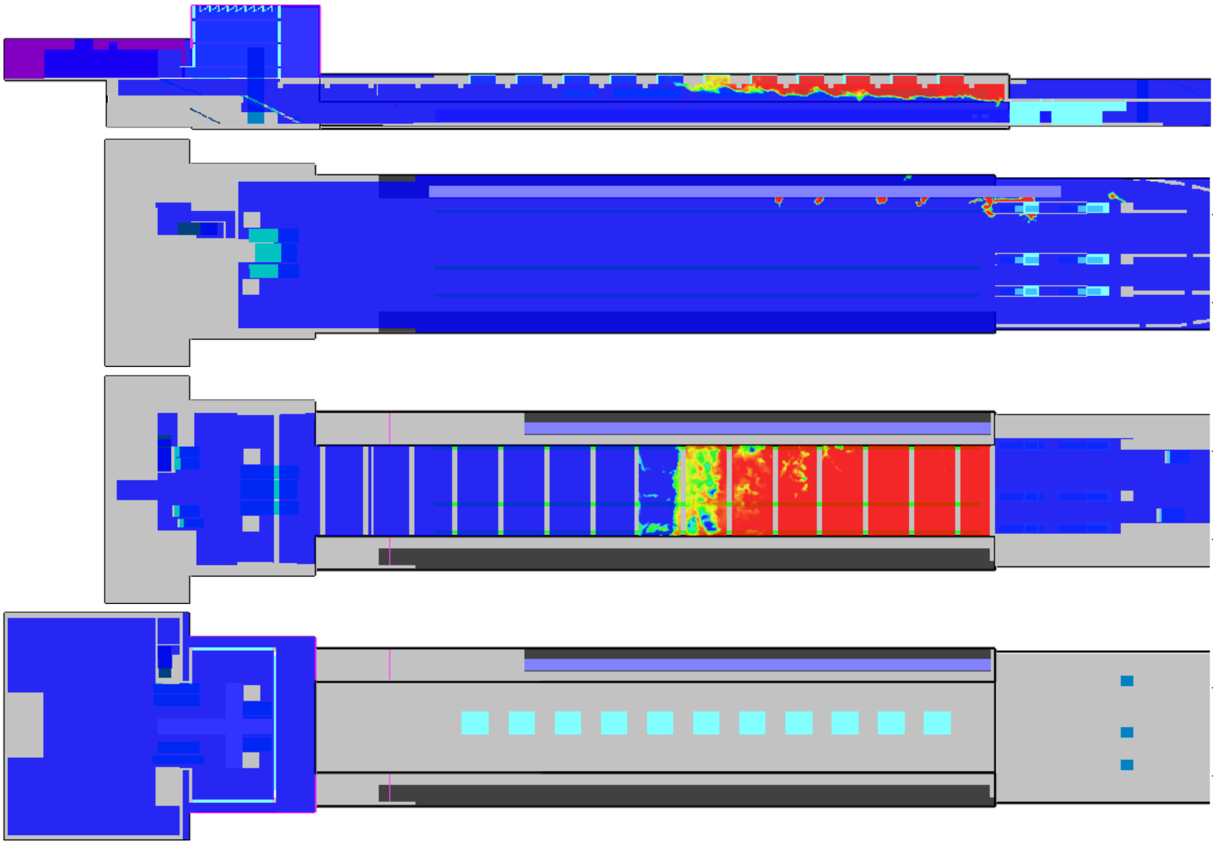


CO

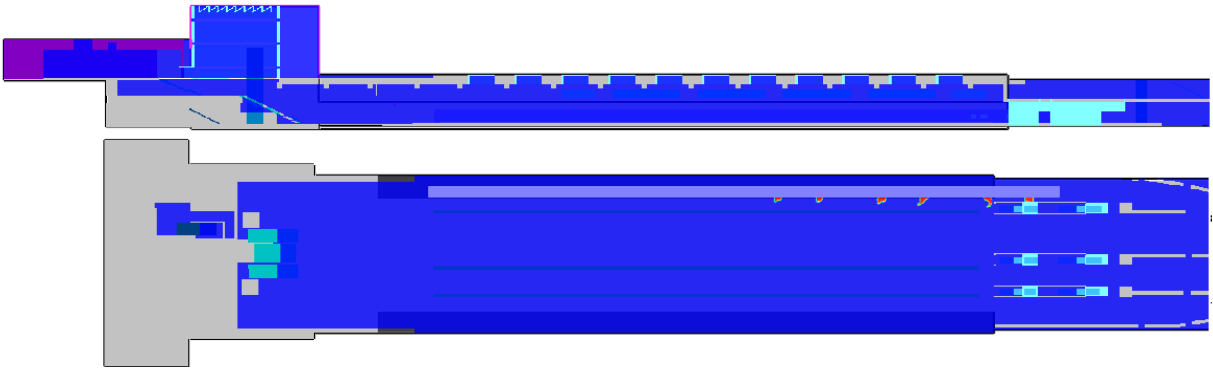


Fire Scenario 3P - Time = 360 seconds

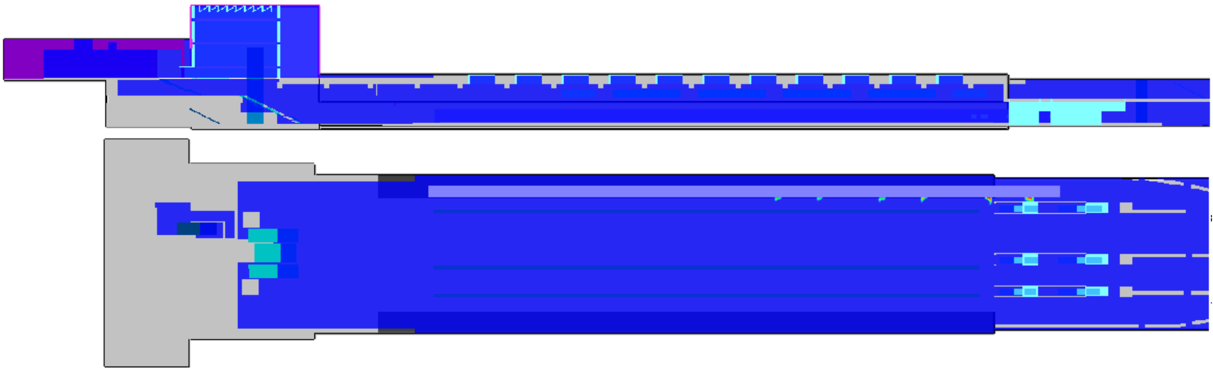
Visibility



Temperature

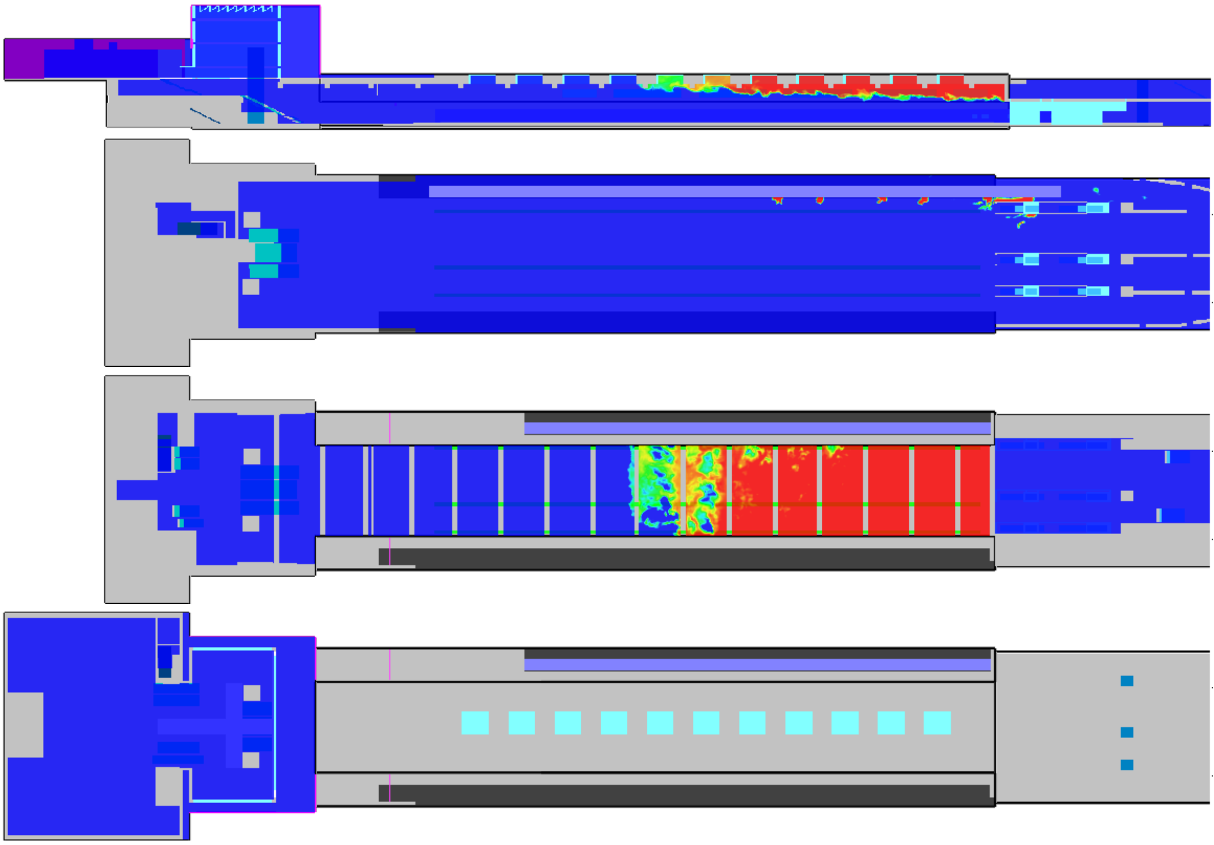


CO

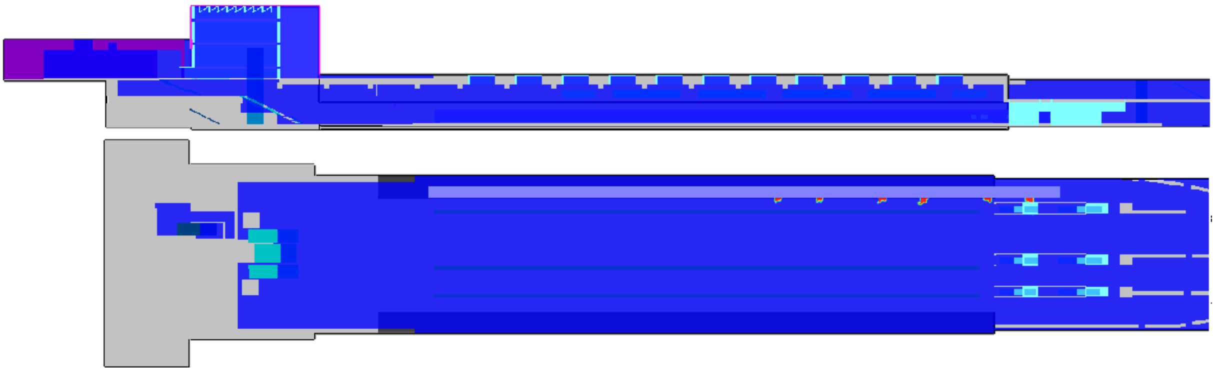


Fire Scenario 3P - Time = 480 seconds

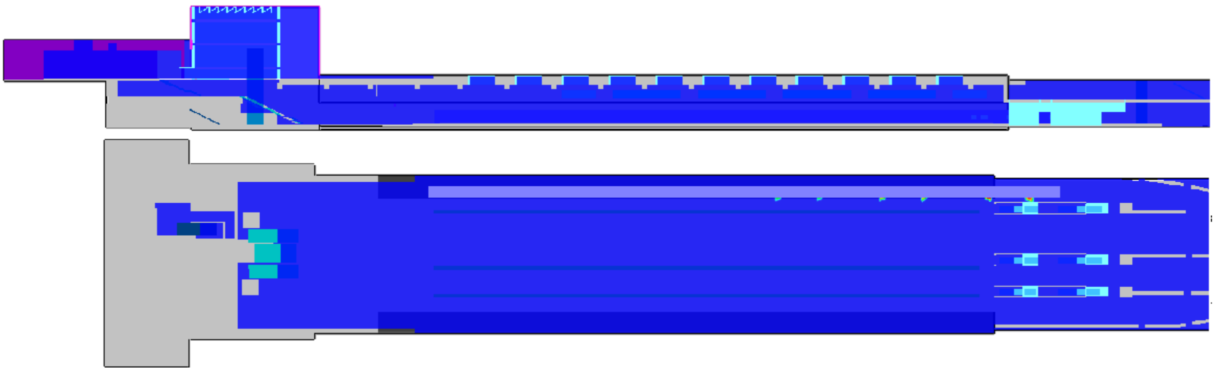
Visibility



Temperature

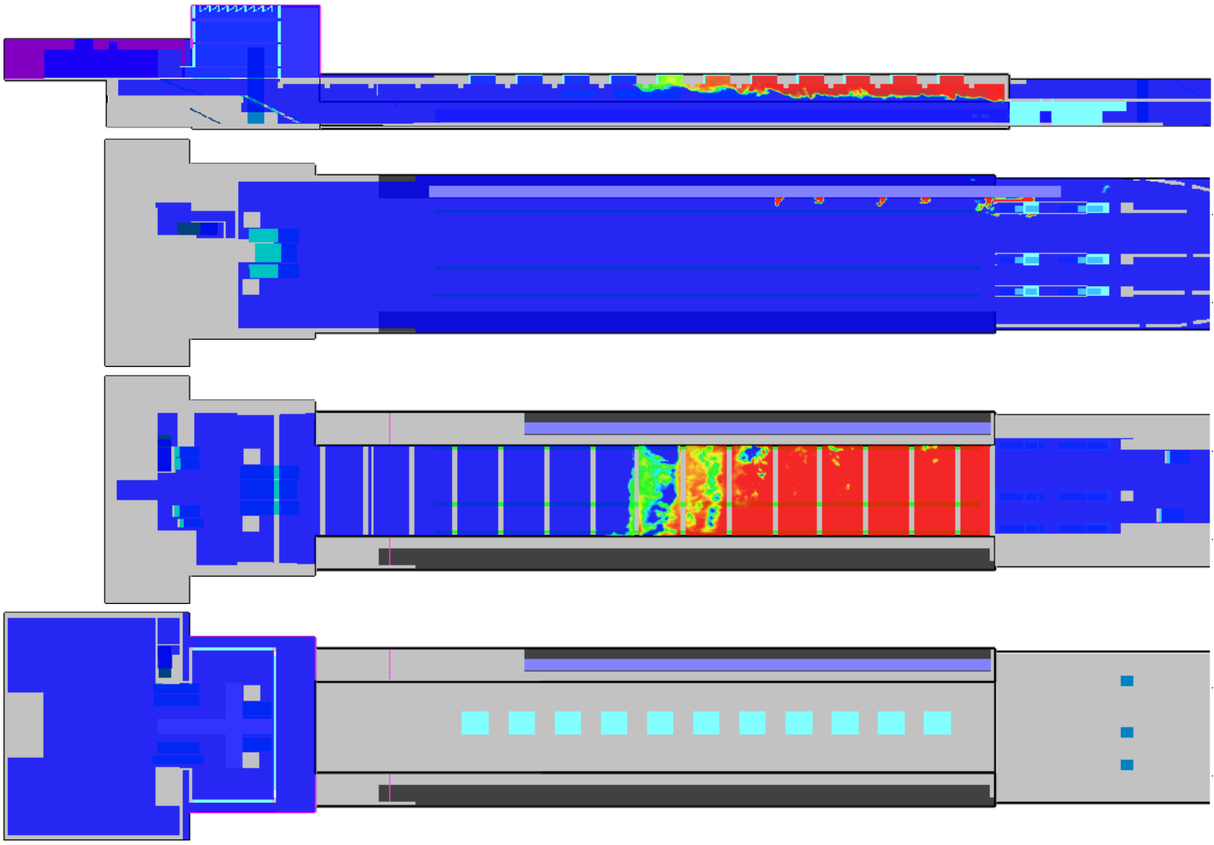


CO

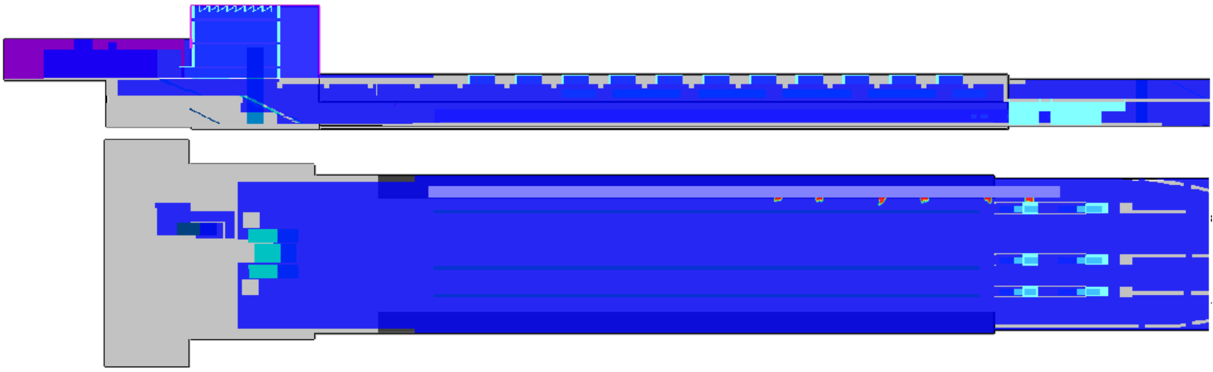


Fire Scenario 3P - Time = 600 seconds

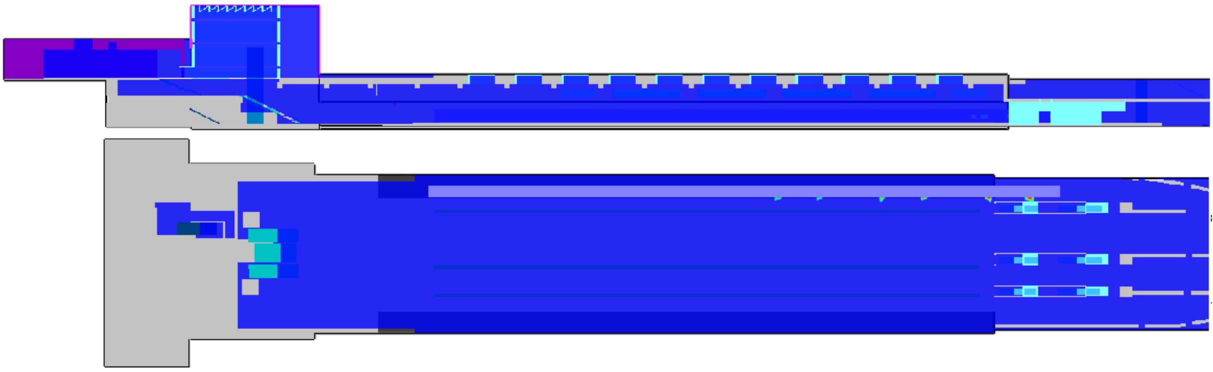
Visibility



Temperature

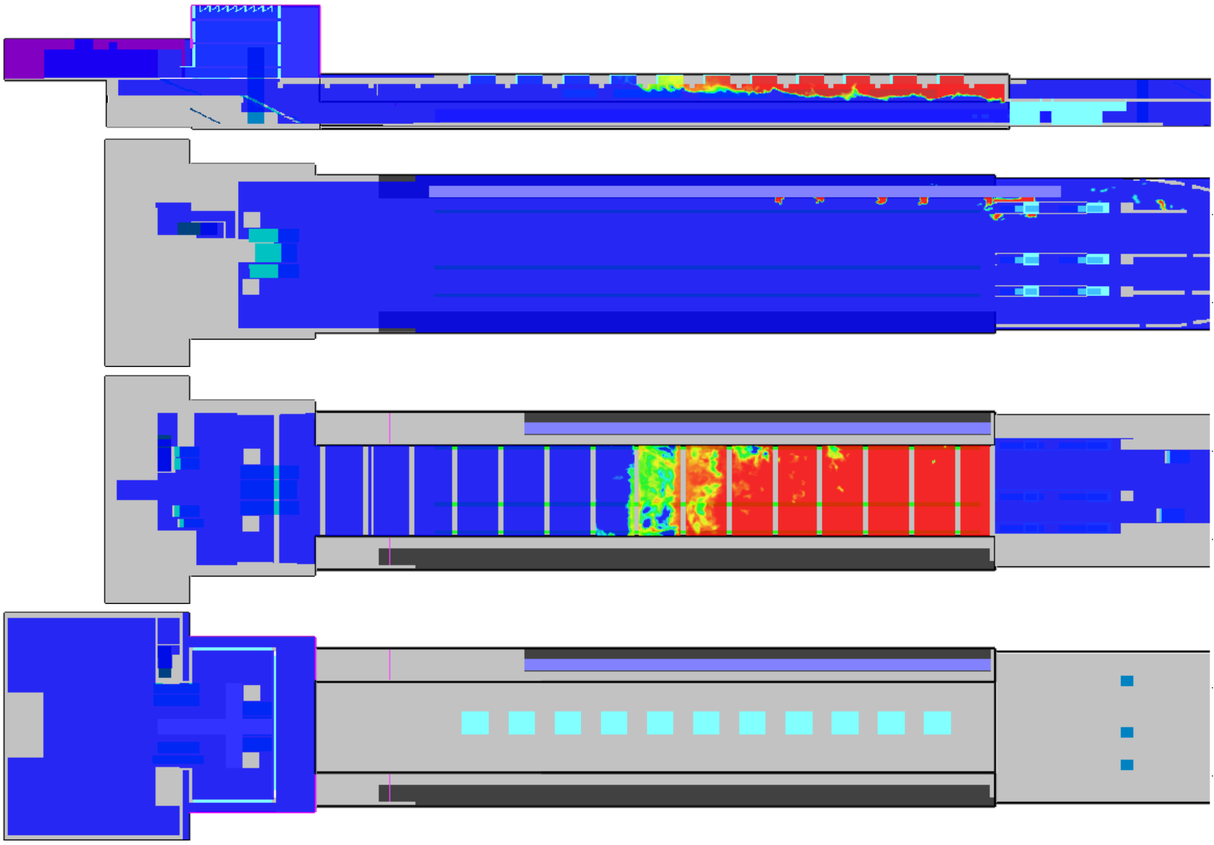


CO

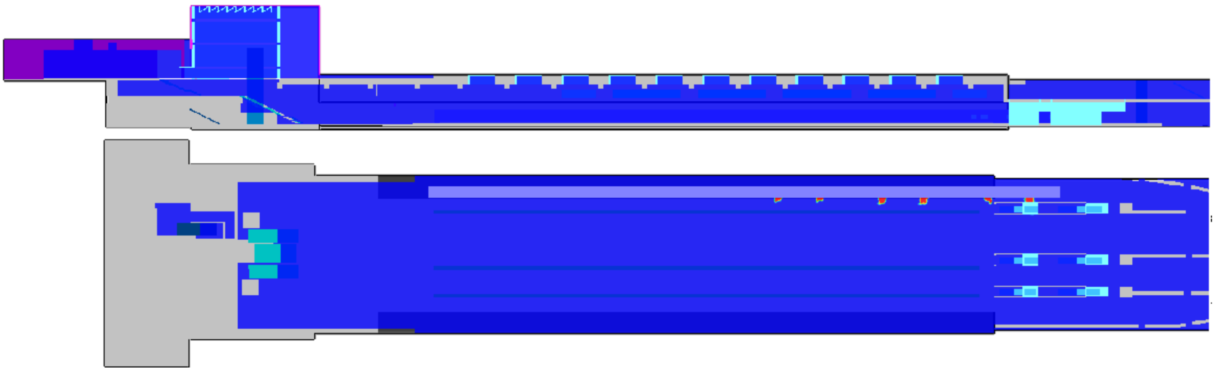


Fire Scenario 3P - Time = 720 seconds

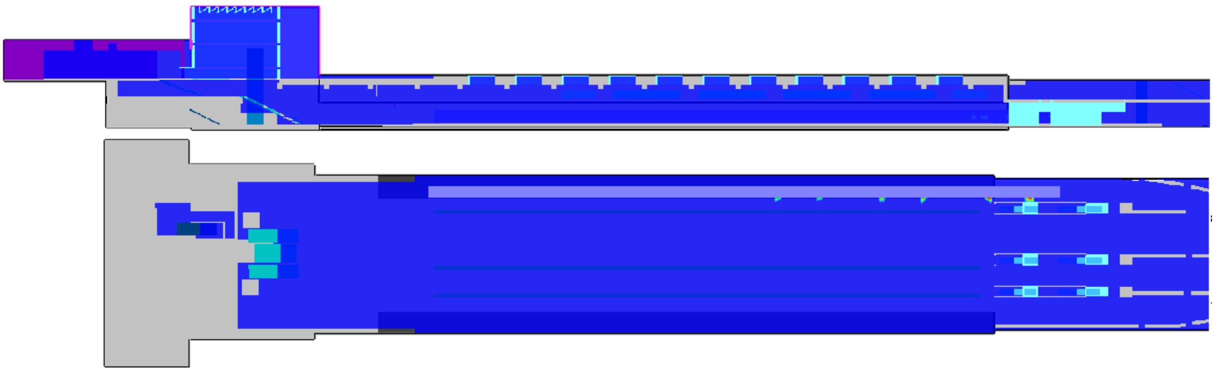
Visibility



Temperature

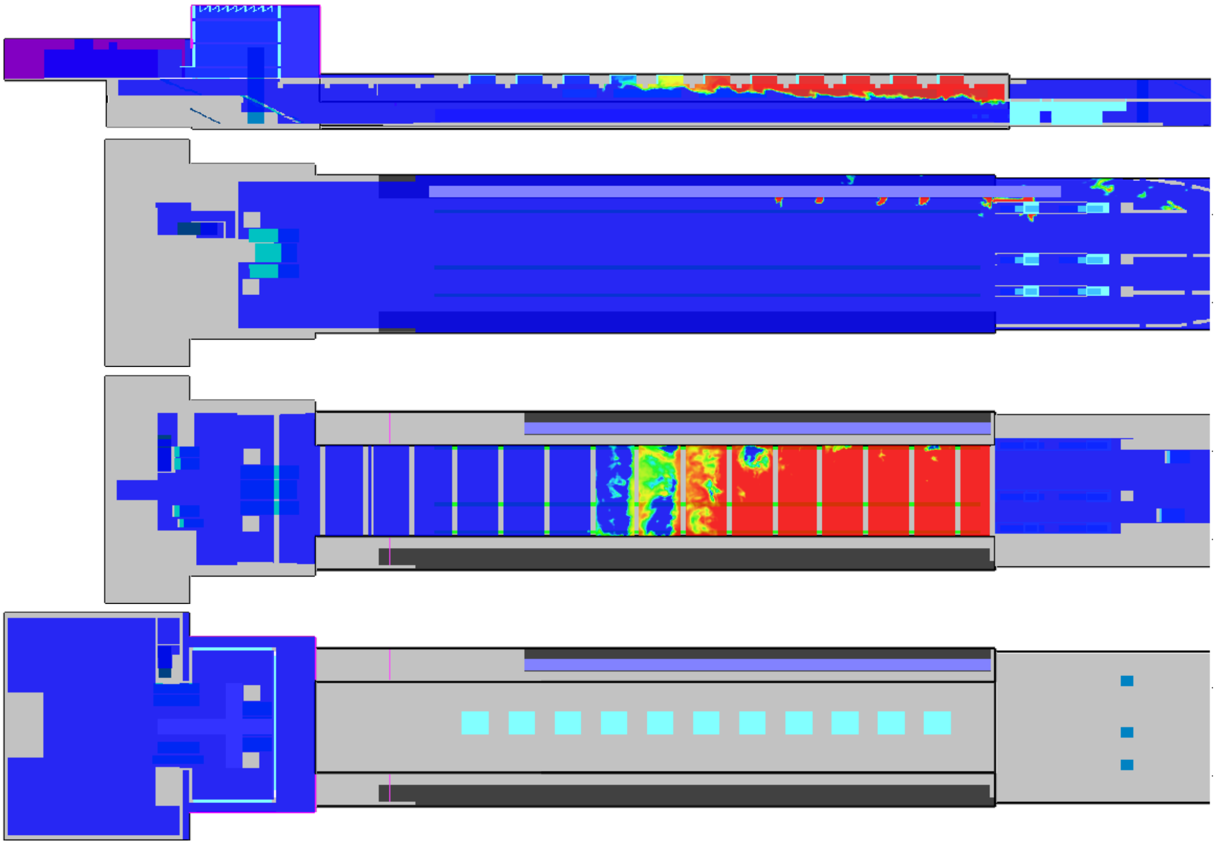


CO

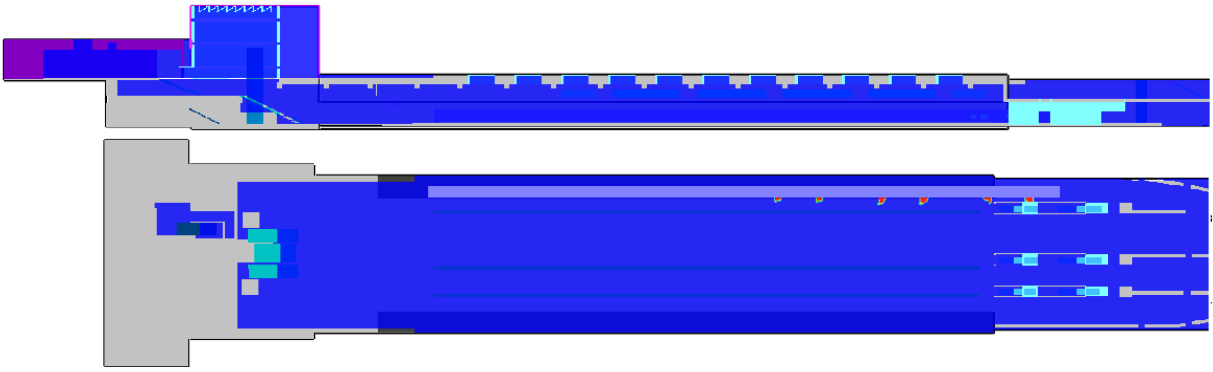


Fire Scenario 3P - Time = 840 seconds

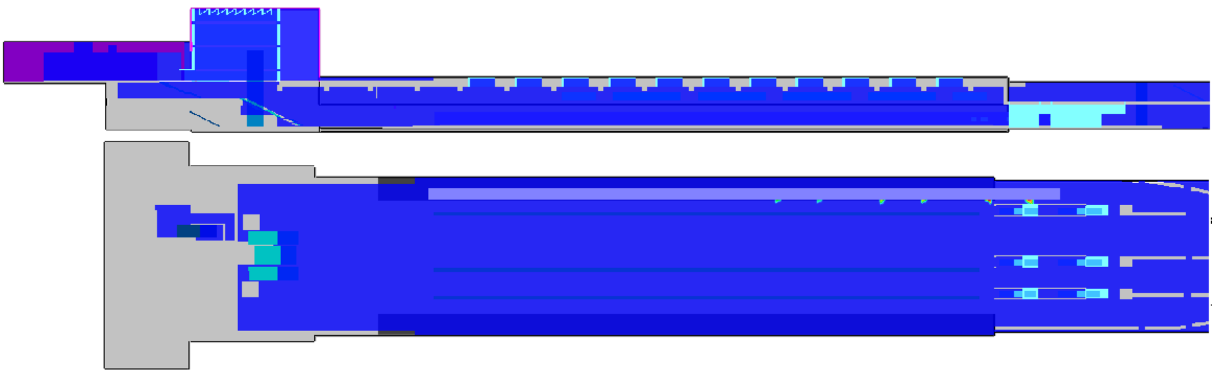
Visibility



Temperature

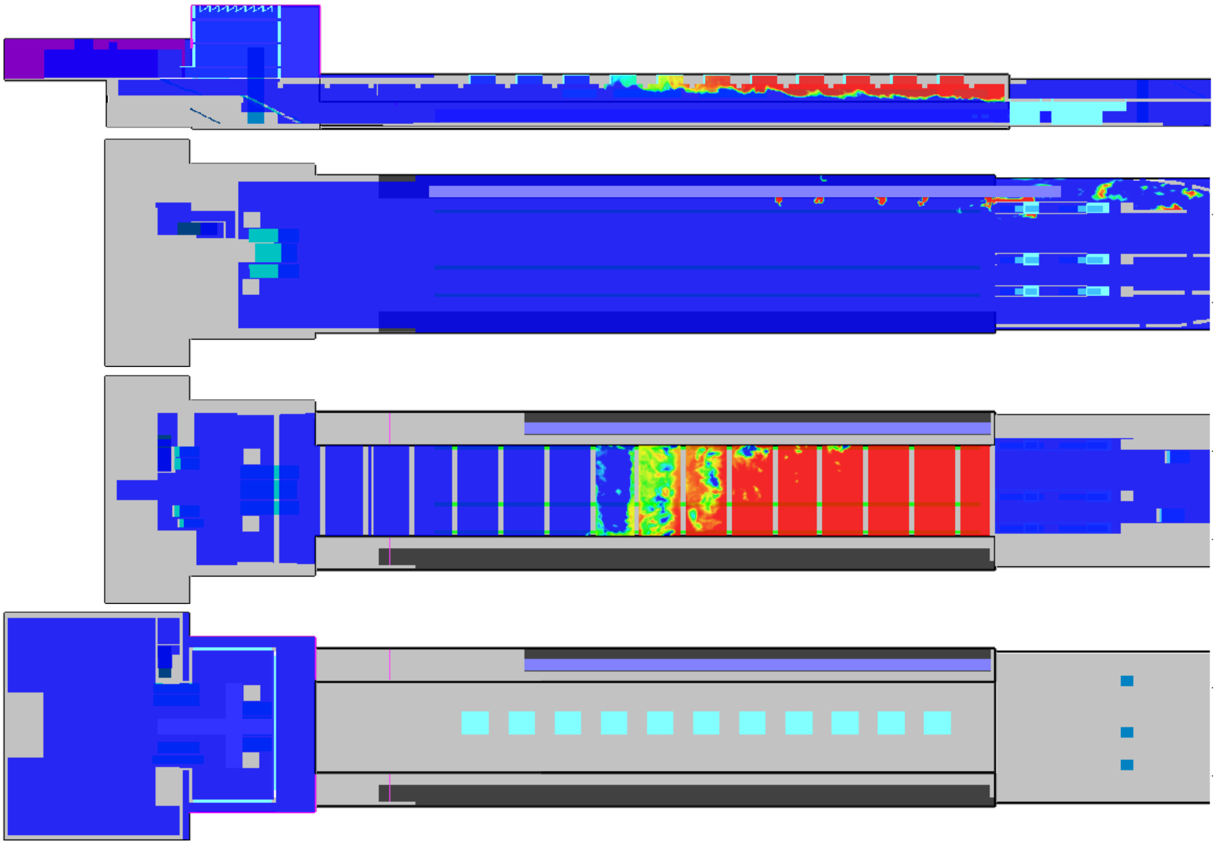


CO

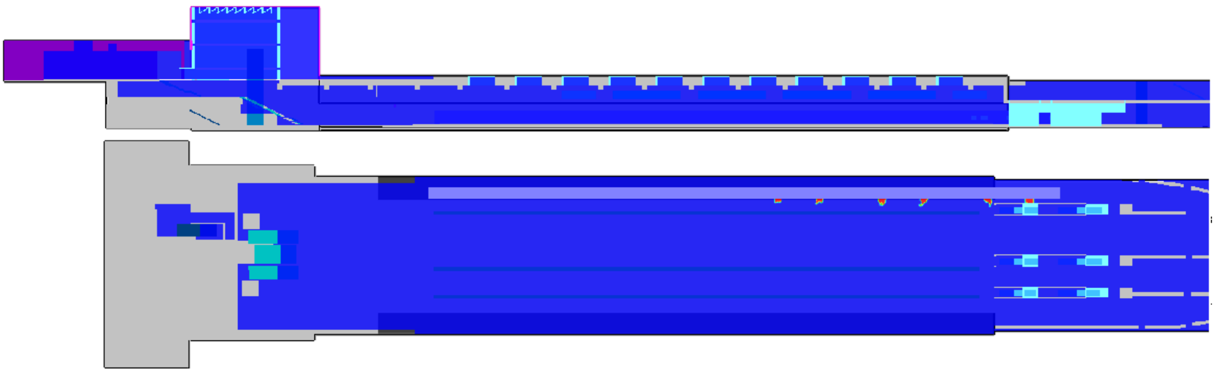


Fire Scenario 3P - Time = 960 seconds

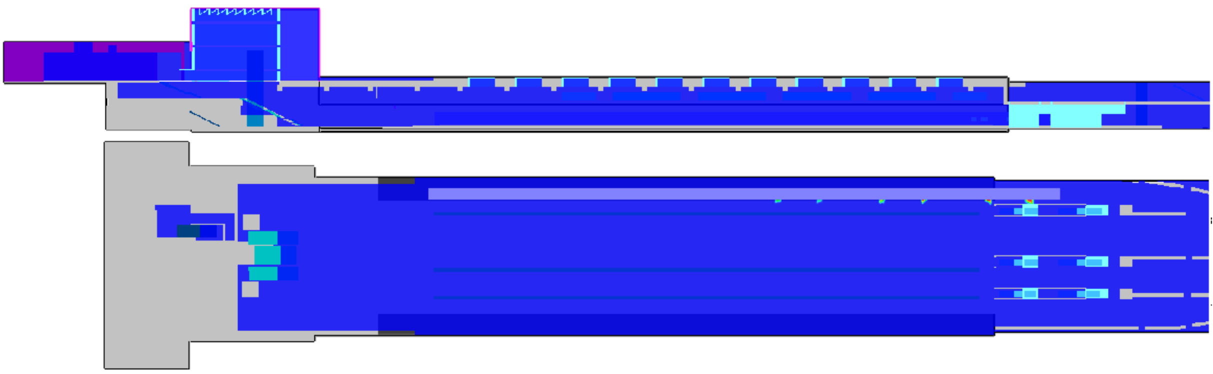
Visibility



Temperature

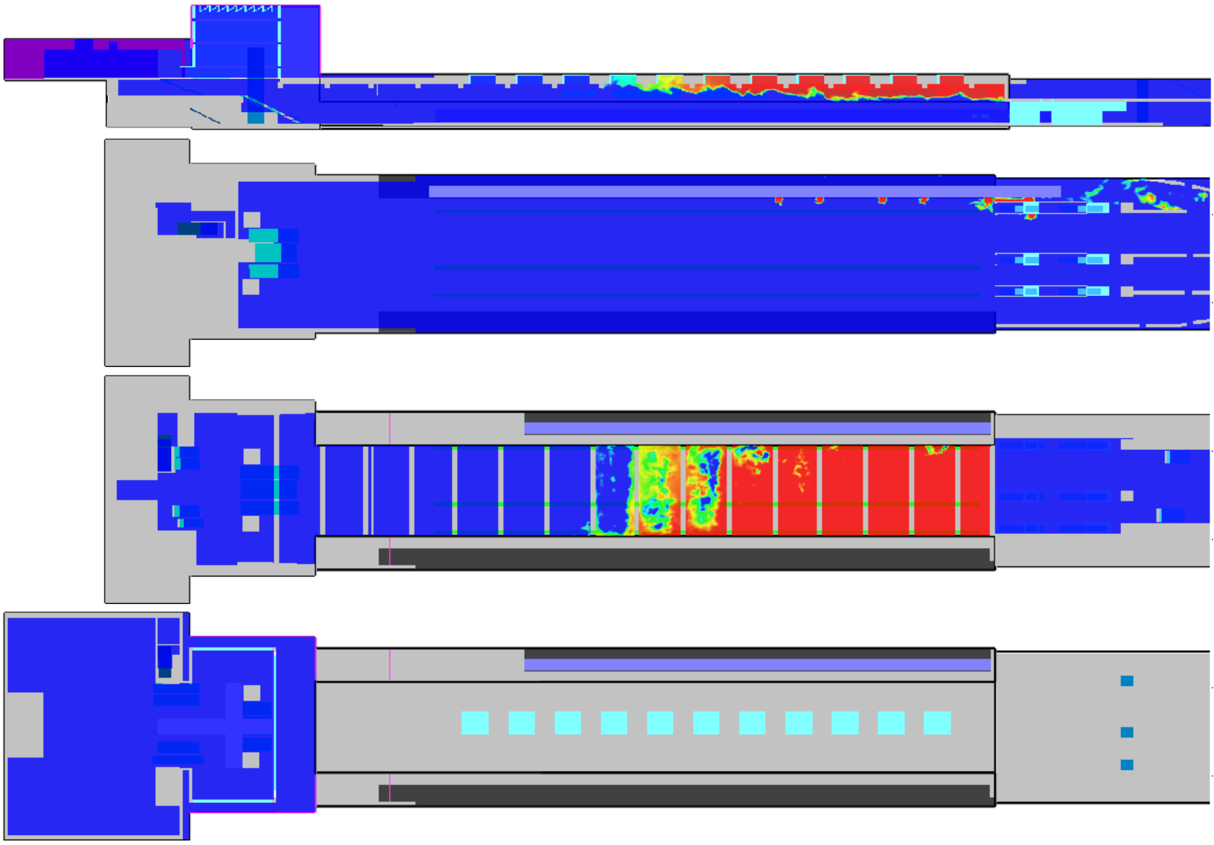


CO

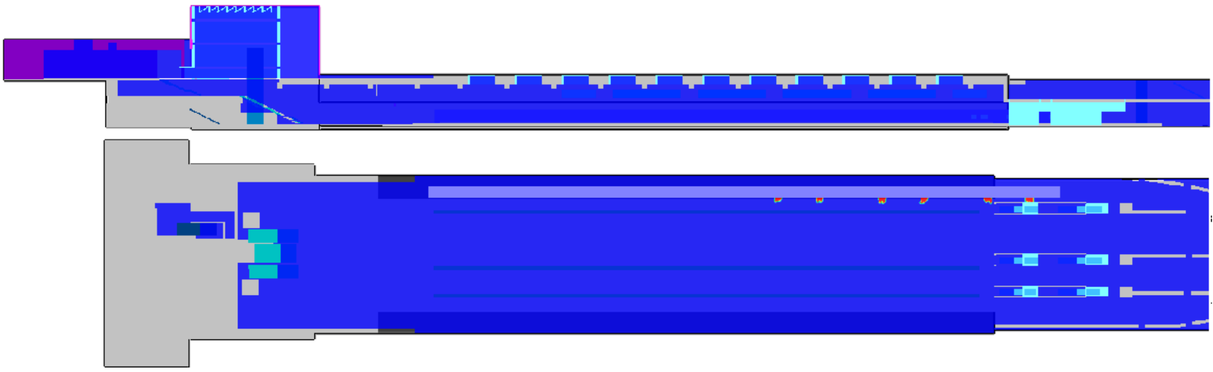


Fire Scenario 3P - Time = 972 seconds

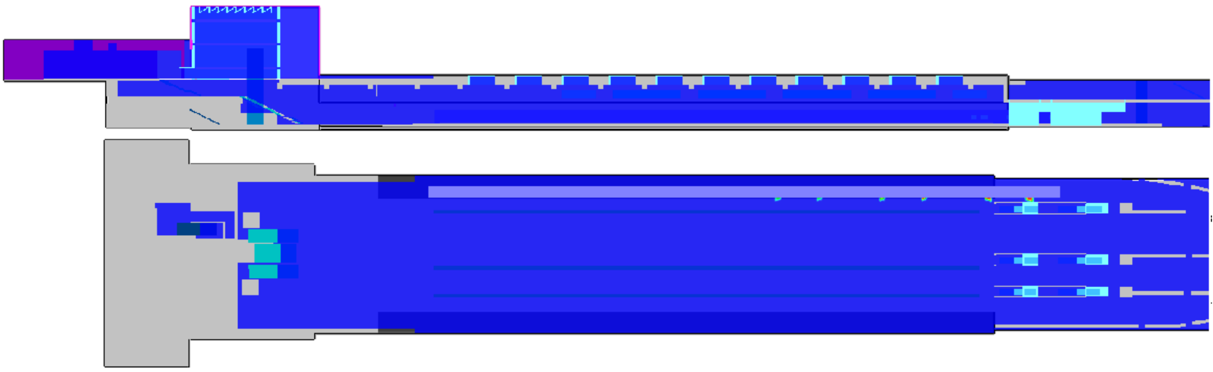
Visibility

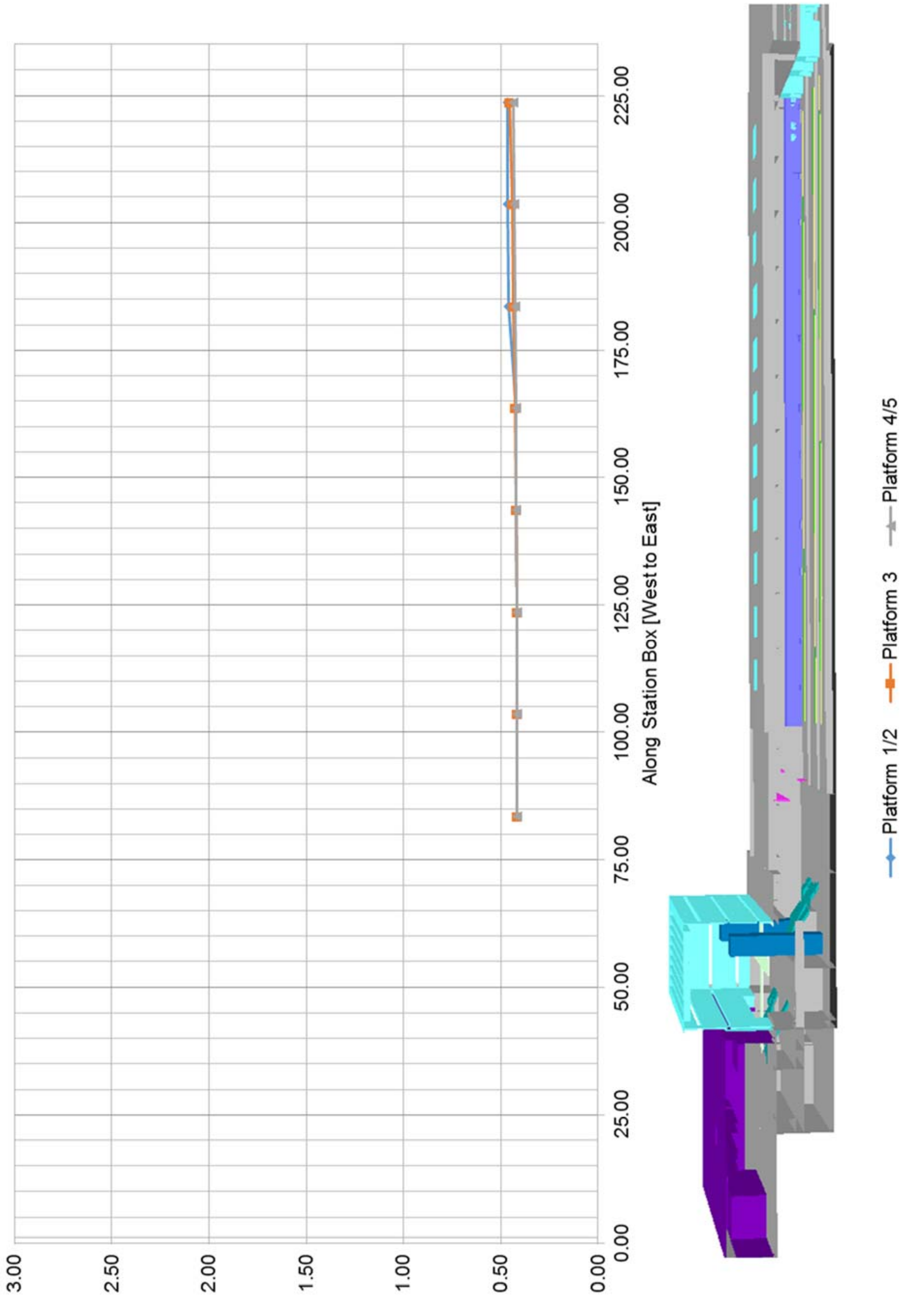


Temperature



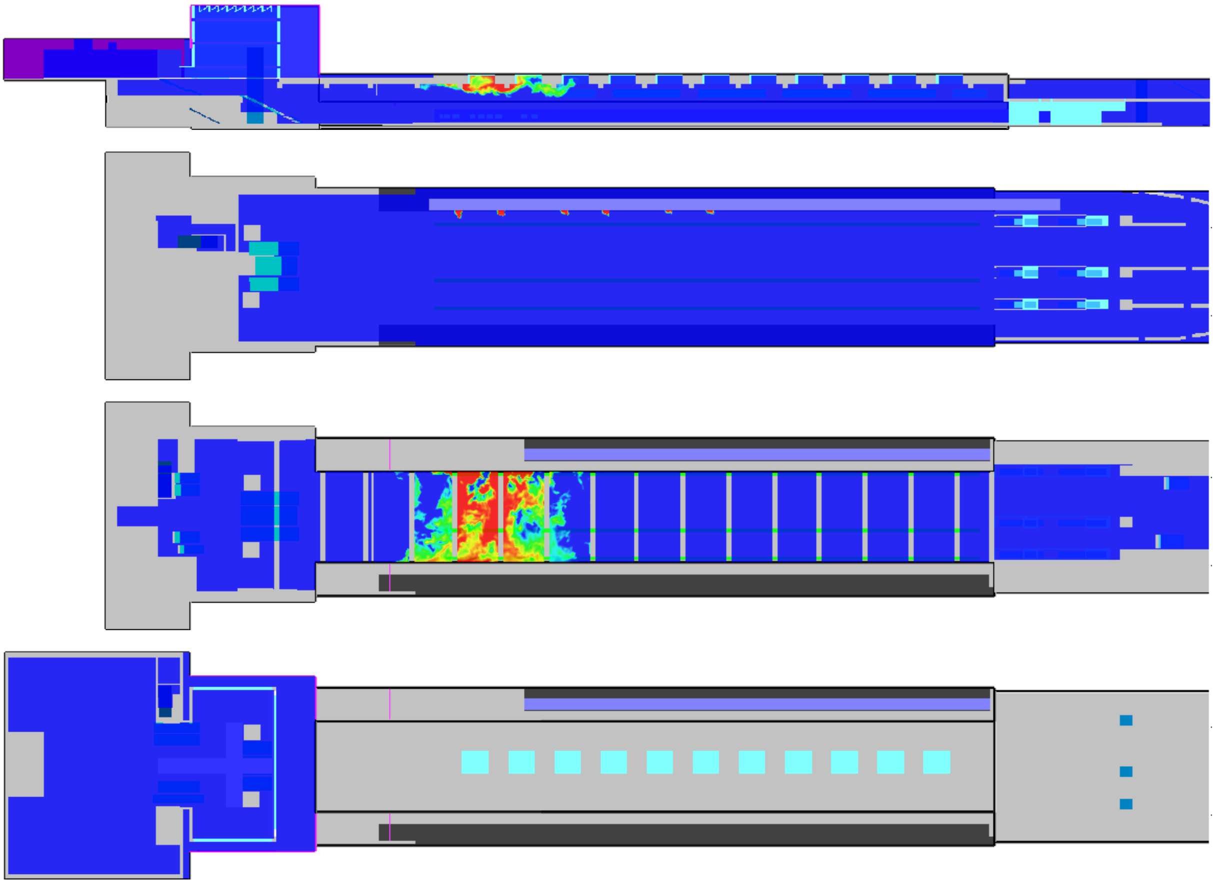
CO



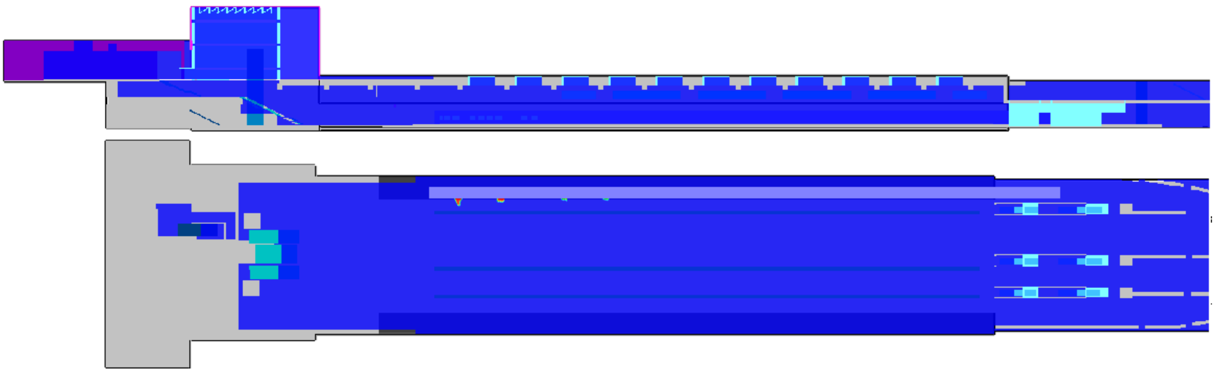

Radiation Heat Flux kW/m²
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
Along Station Box [West to East]
Platform 1/2
Platform 3
Platform 4/5

Fire Scenario 5P - Time = 120 seconds

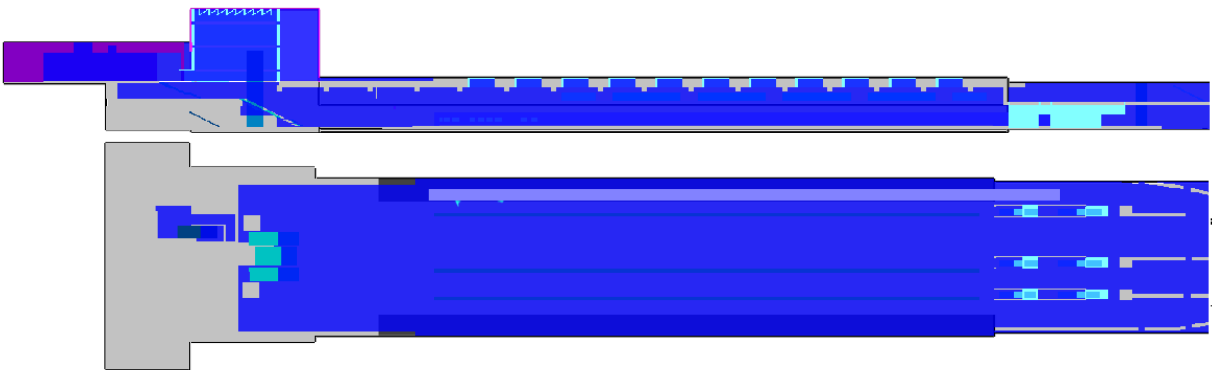
Visibility



Temperature

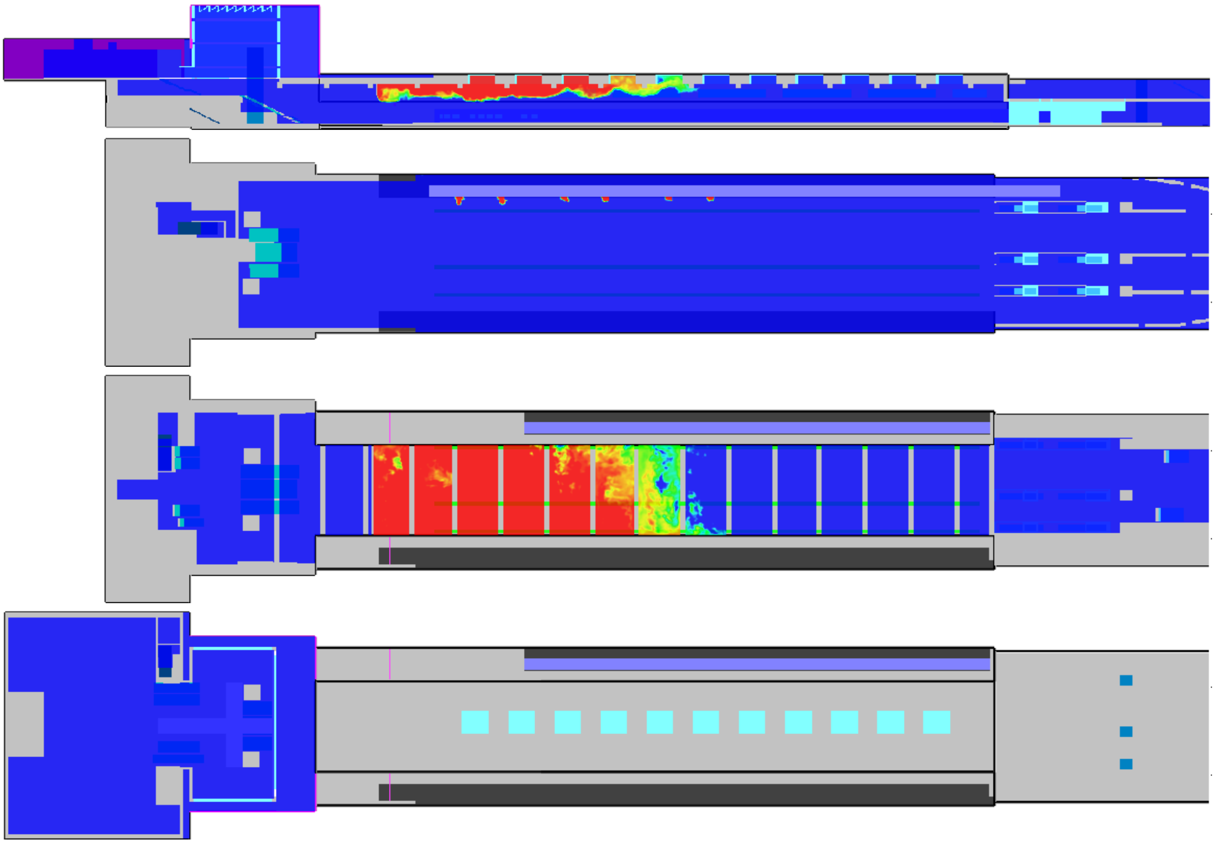


CO

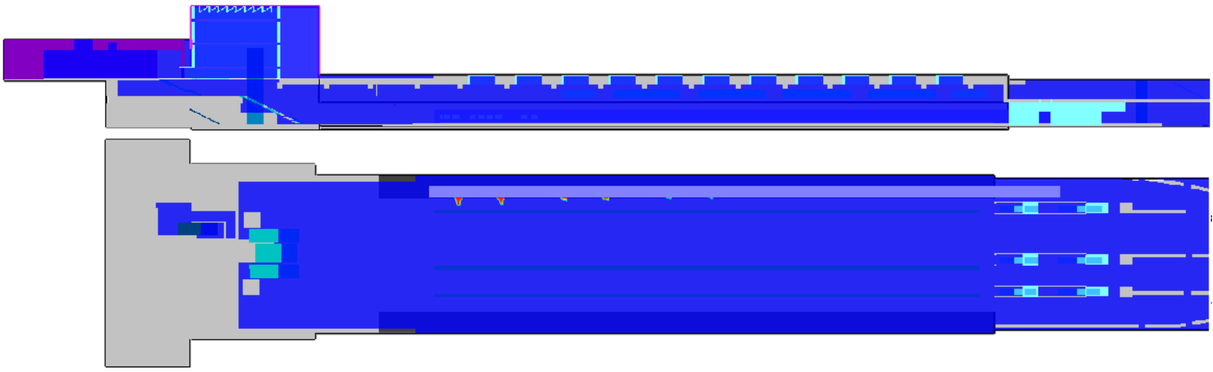


Fire Scenario 5P - Time = 240 seconds

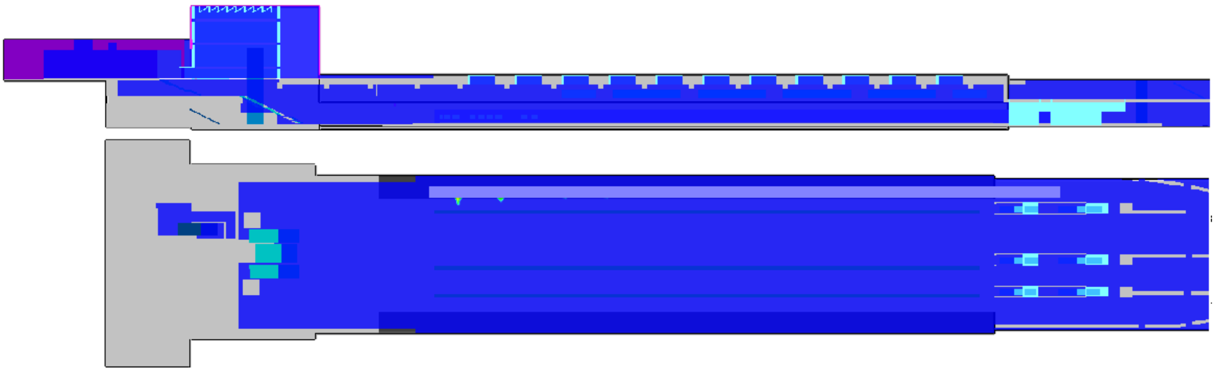
Visibility



Temperature

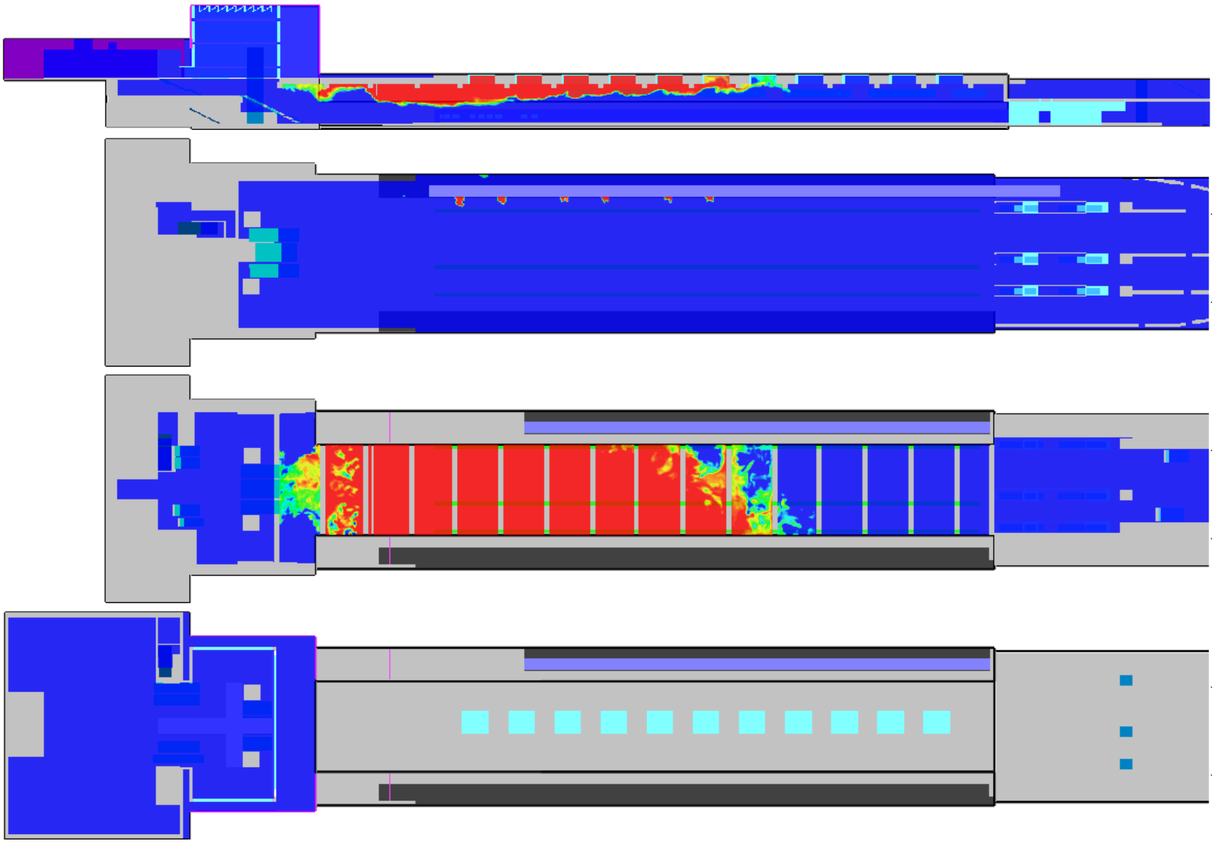


CO

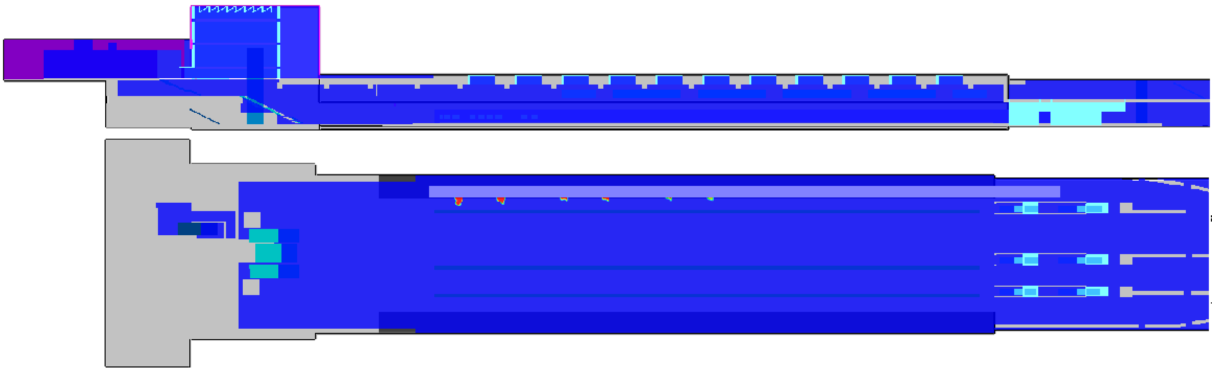


Fire Scenario 5P - Time = 360 seconds

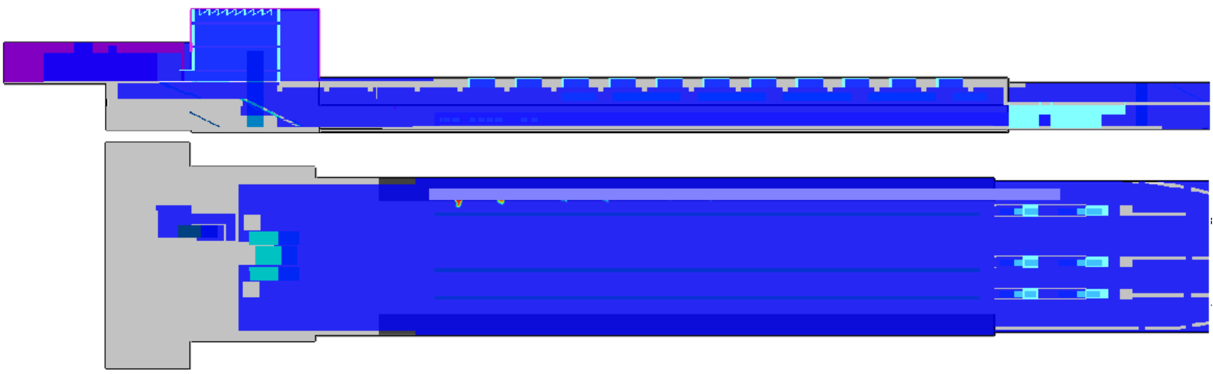
Visibility



Temperature

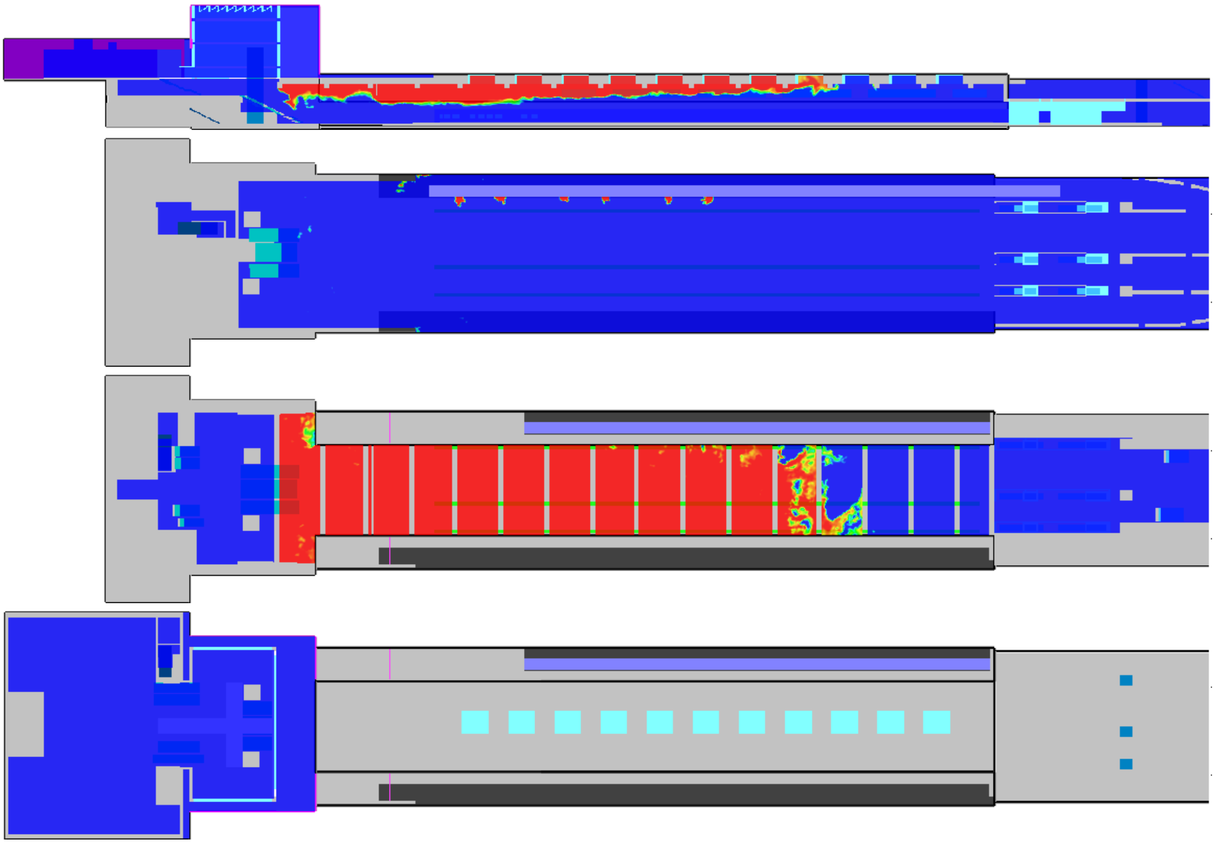


CO

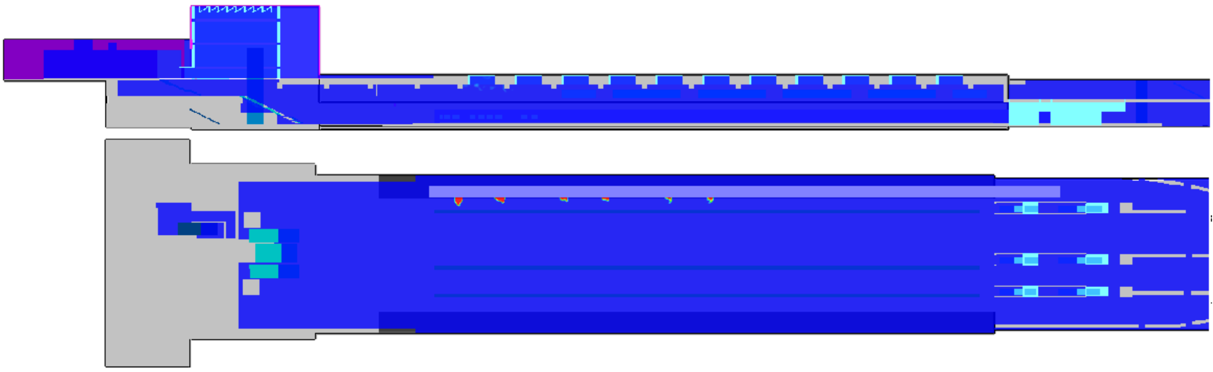


Fire Scenario 5P - Time = 480 seconds

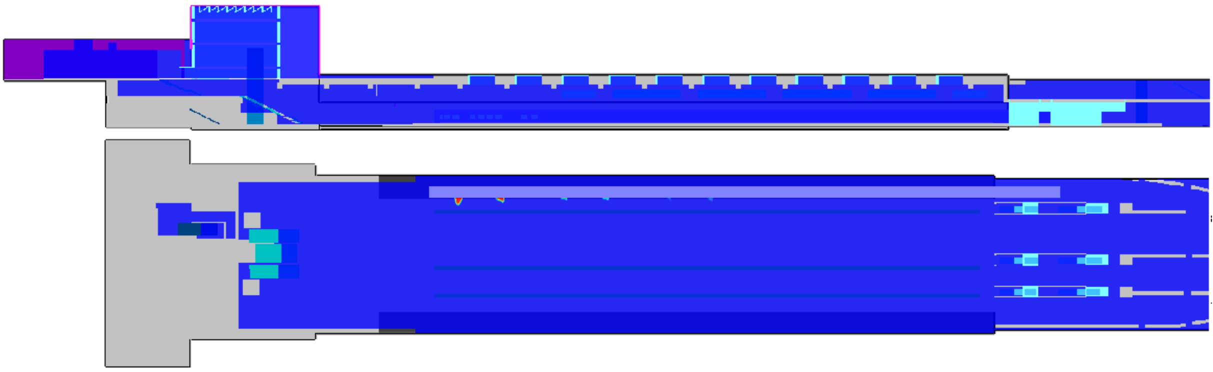
Visibility



Temperature

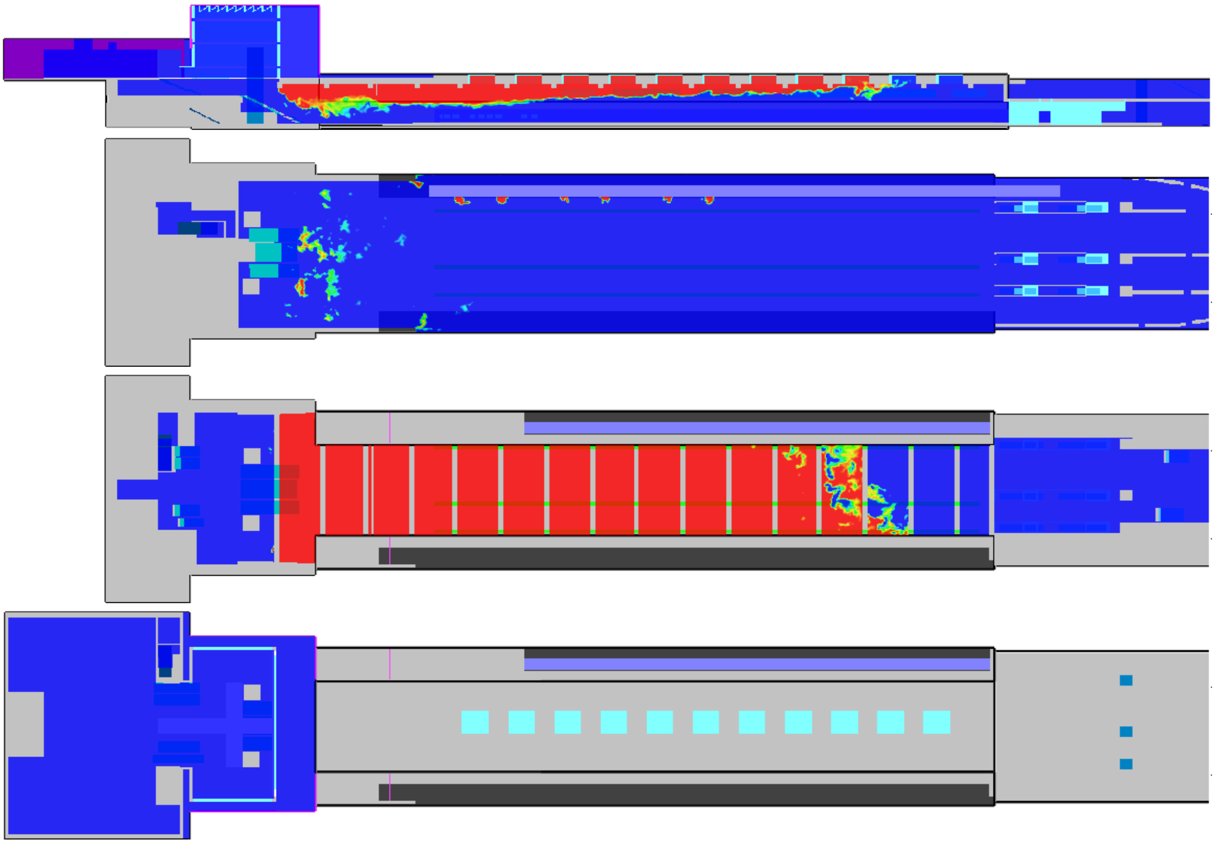


CO

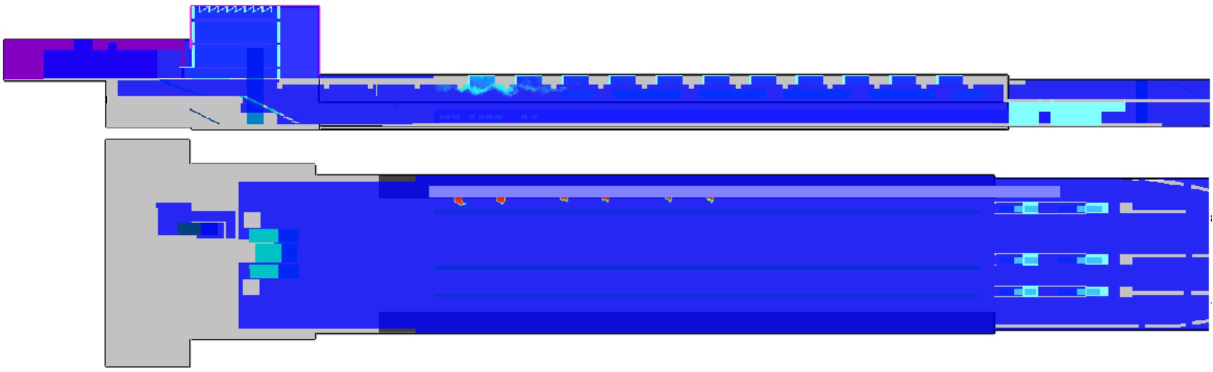


Fire Scenario 5P - Time = 600 seconds

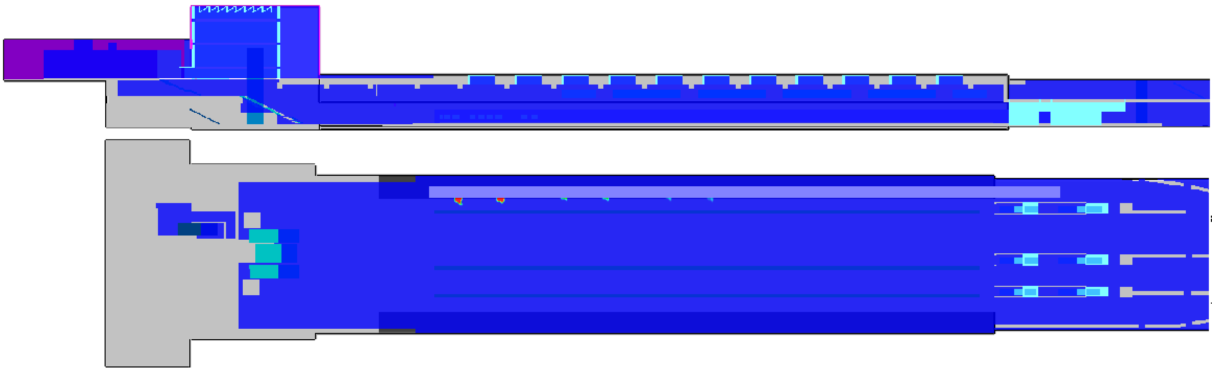
Visibility



Temperature

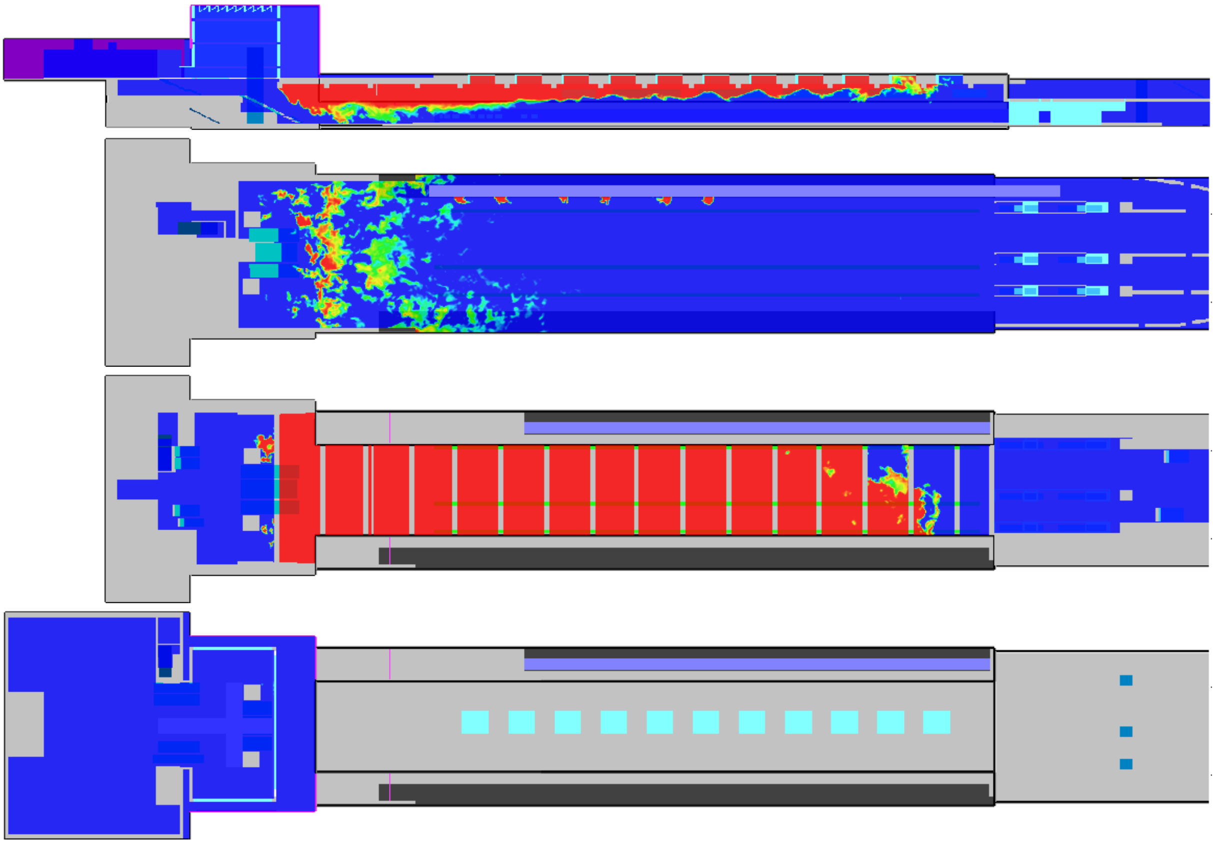


CO

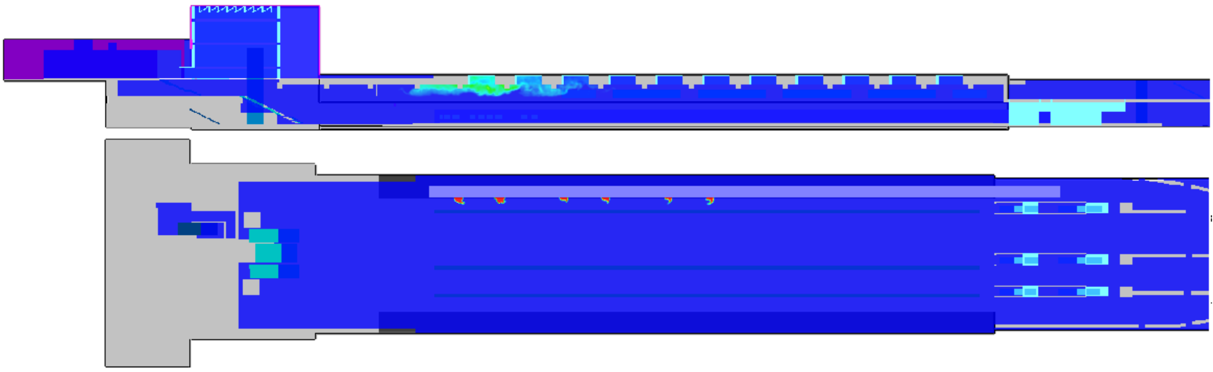


Fire Scenario 5P - Time = 720 seconds

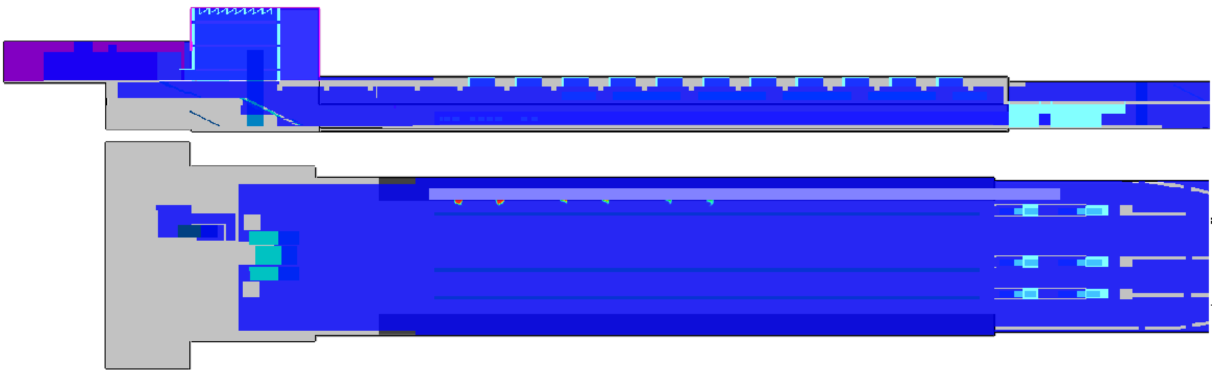
Visibility



Temperature

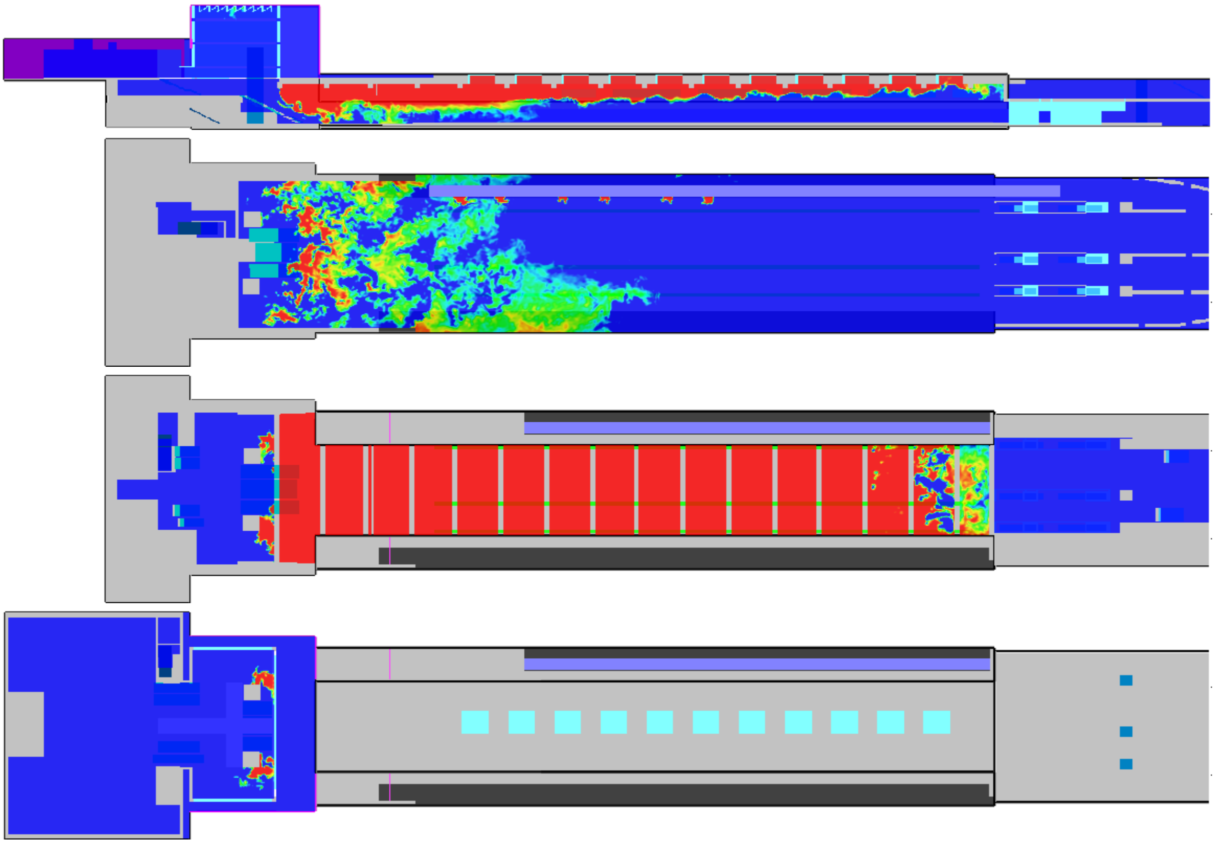


CO

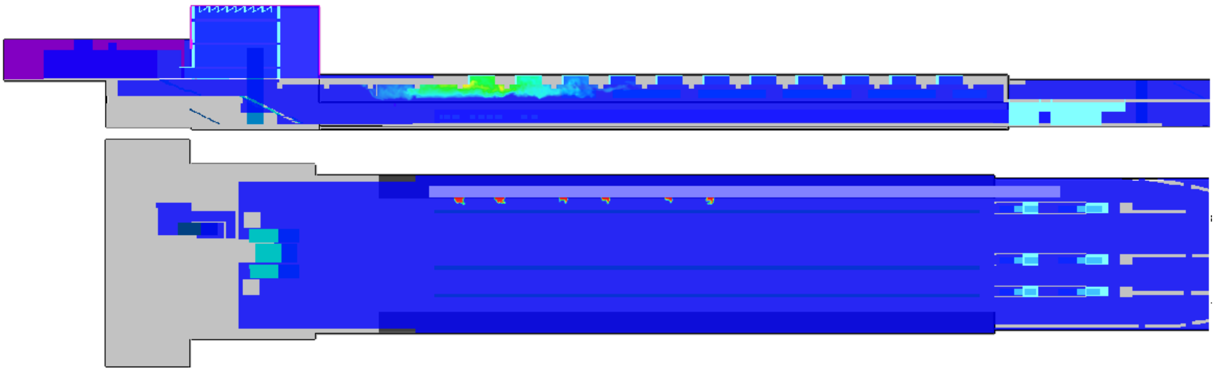


Fire Scenario 5P - Time = 840 seconds

Visibility



Temperature



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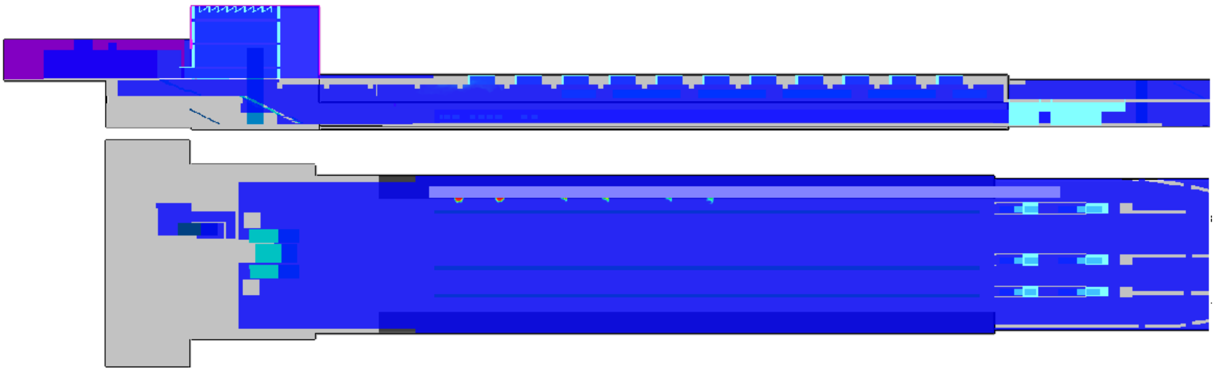
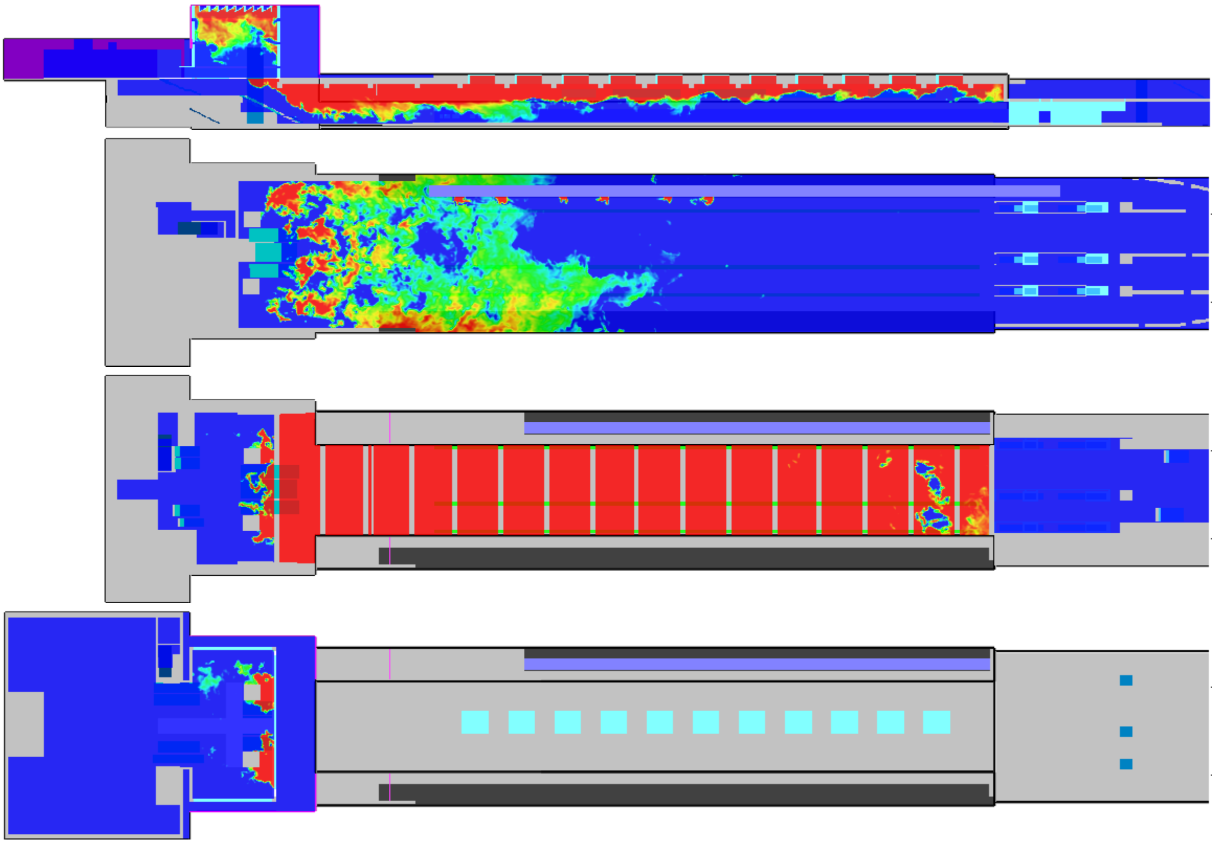
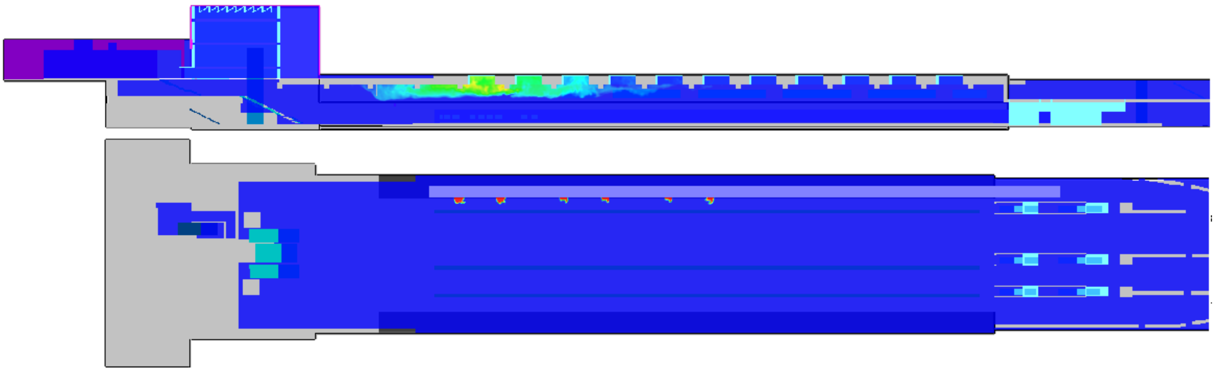


Fire Scenario 5P - Time = 960 seconds

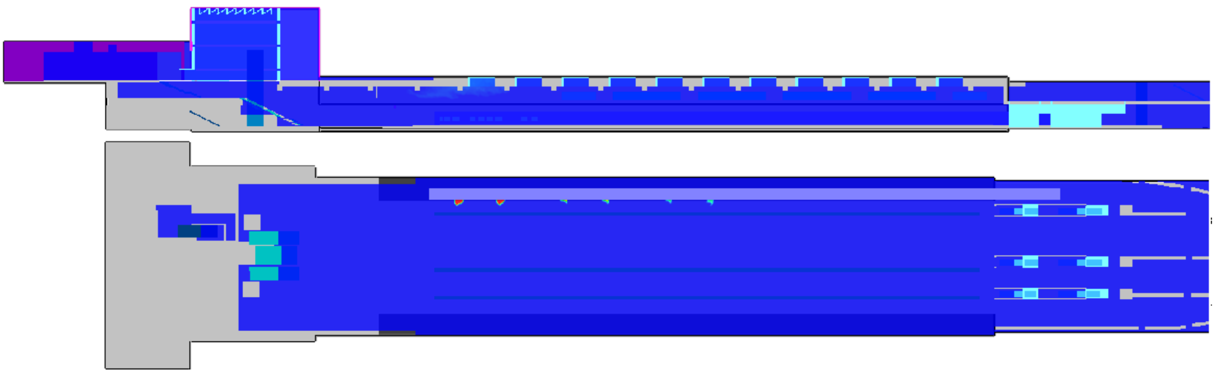
Visibility



Temperature

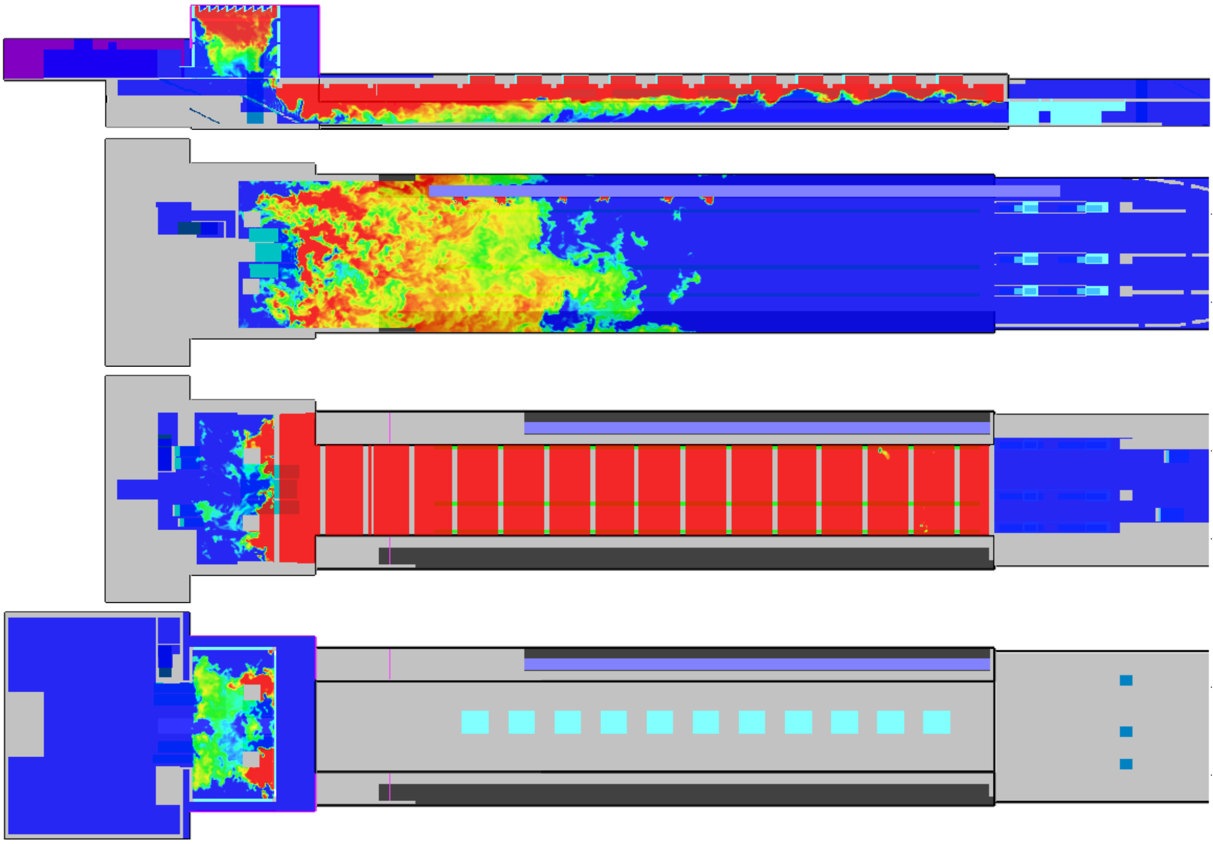


CO

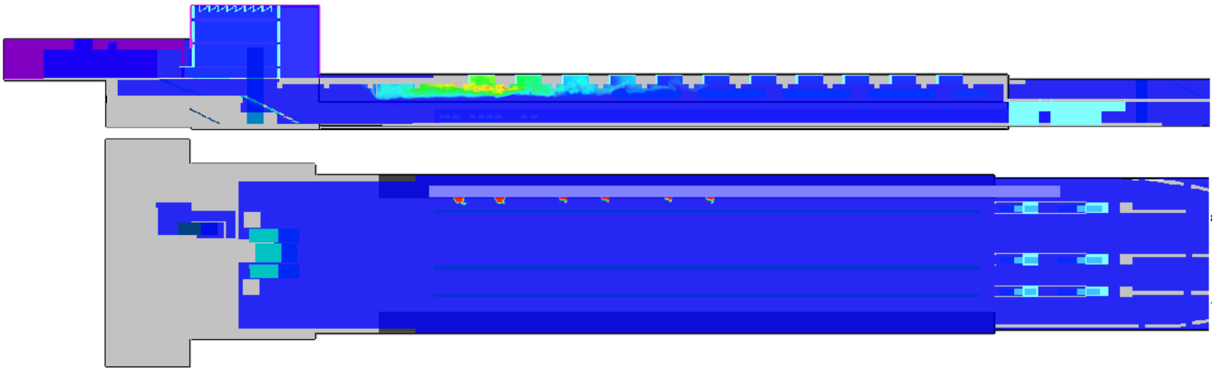


Fire Scenario 5P - Time = 1,200 seconds

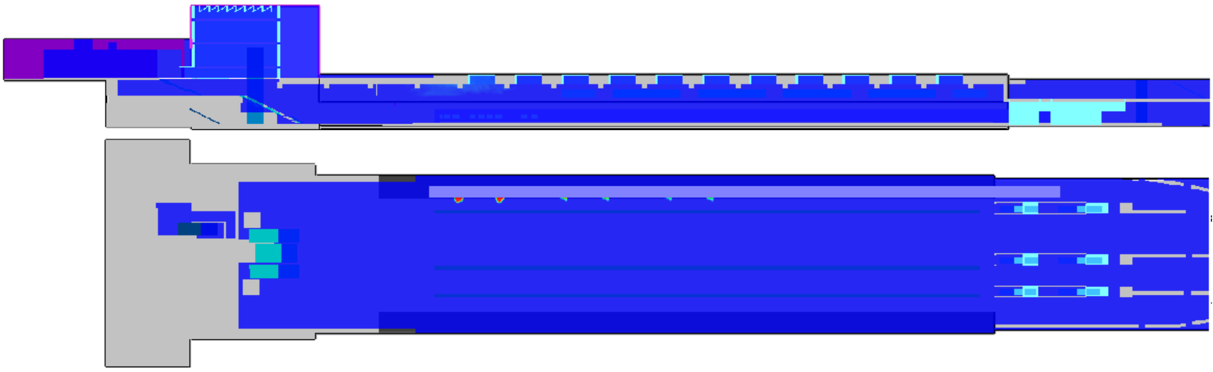
Visibility

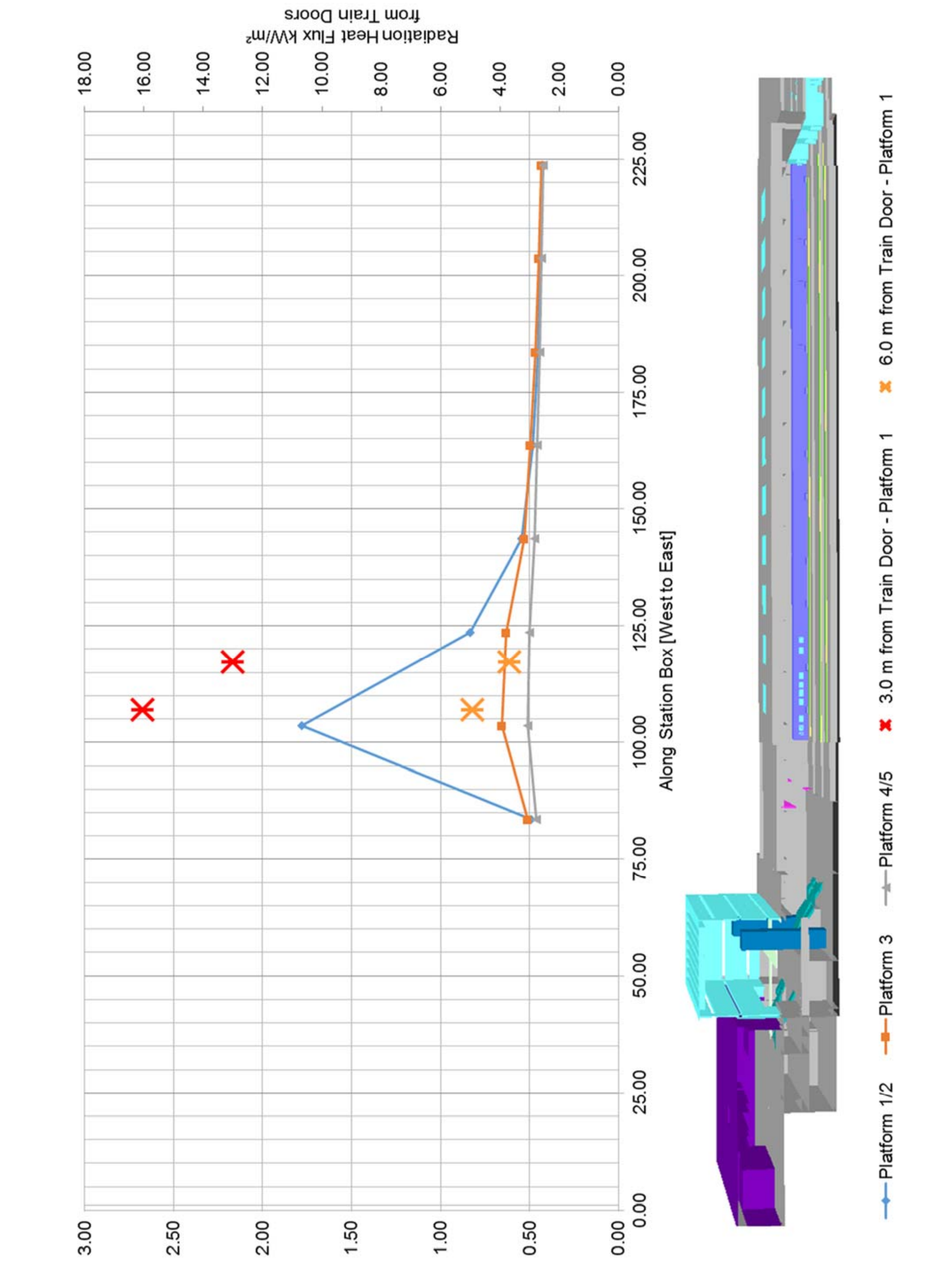


Temperature



CO

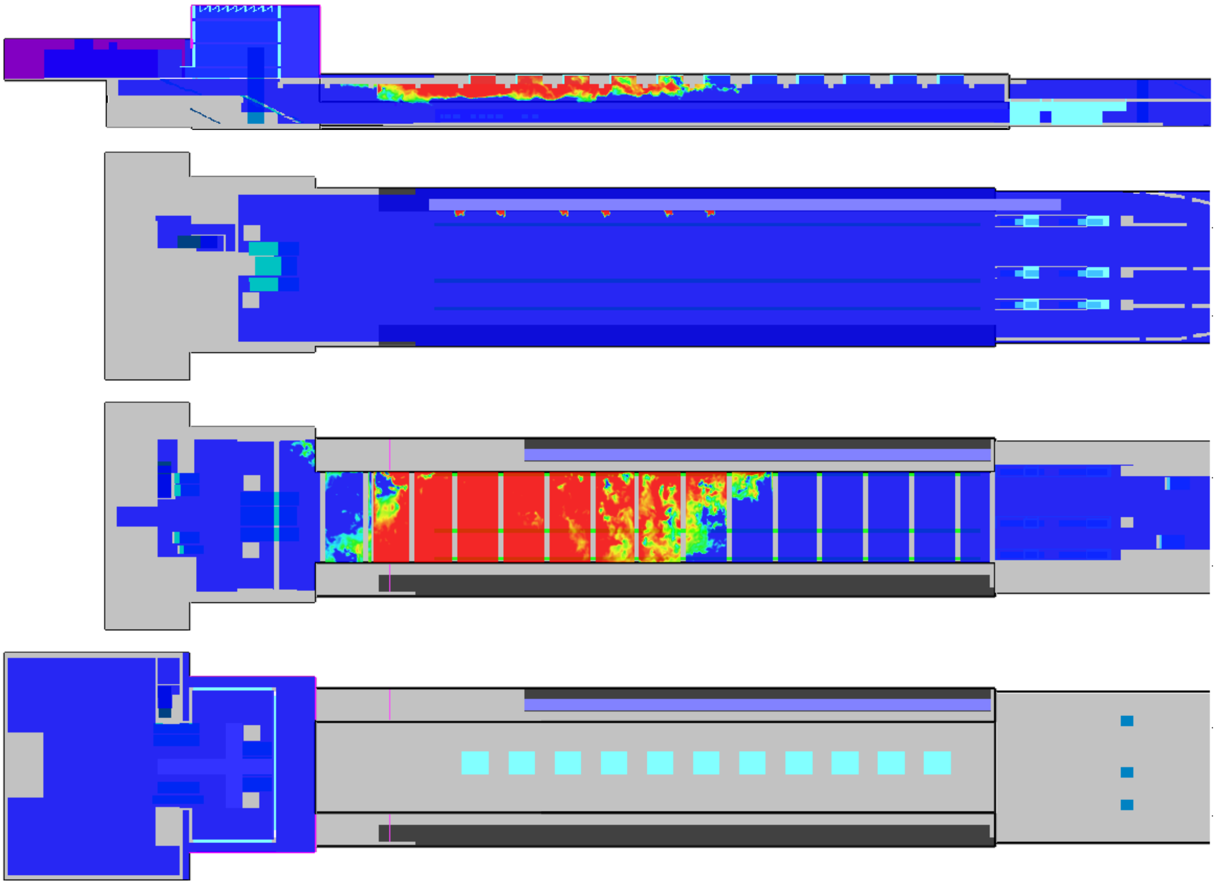




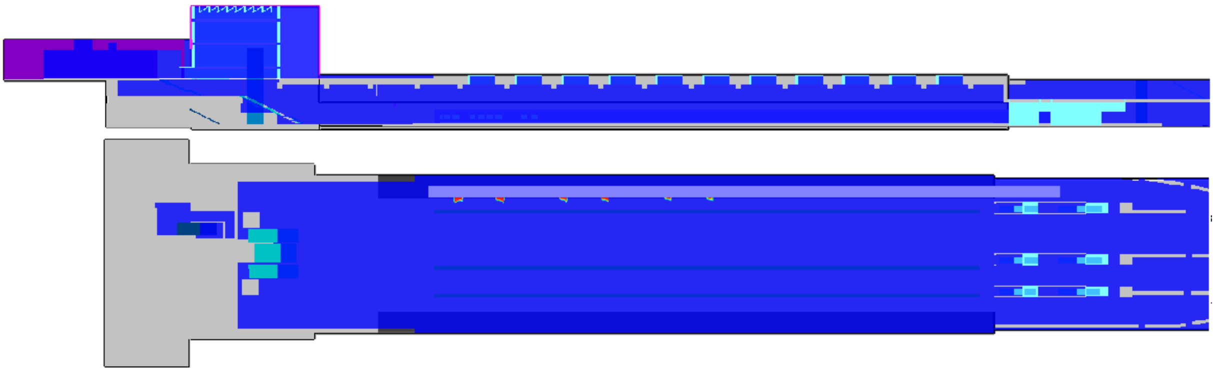
Radiation Heat Flux kW/m²
Radiation Heat Flux kW/m² from Train Doors
Along Station Box [West to East]
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
Platform 1/2
Platform 3
Platform 4/5
3.0 m from Train Door - Platform 1
6.0 m from Train Door - Platform 1

Fire Scenario 6P - Time = 120 seconds

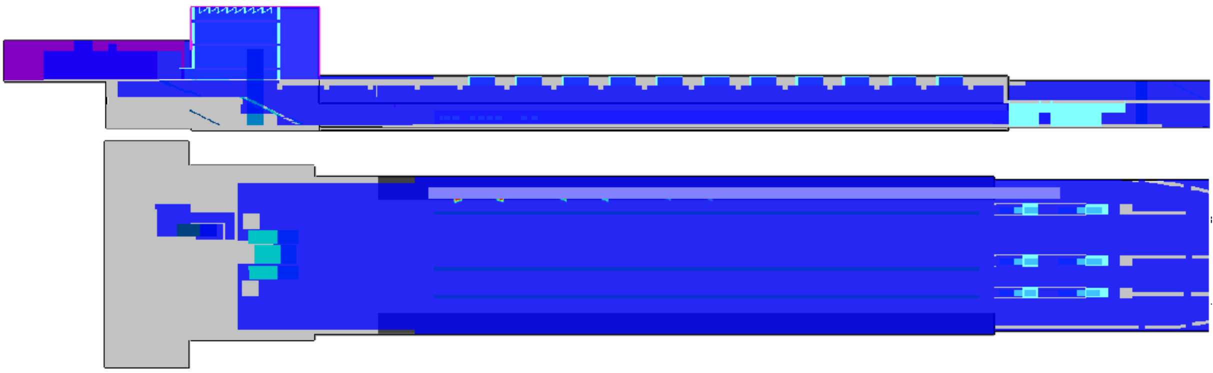
Visibility



Temperature

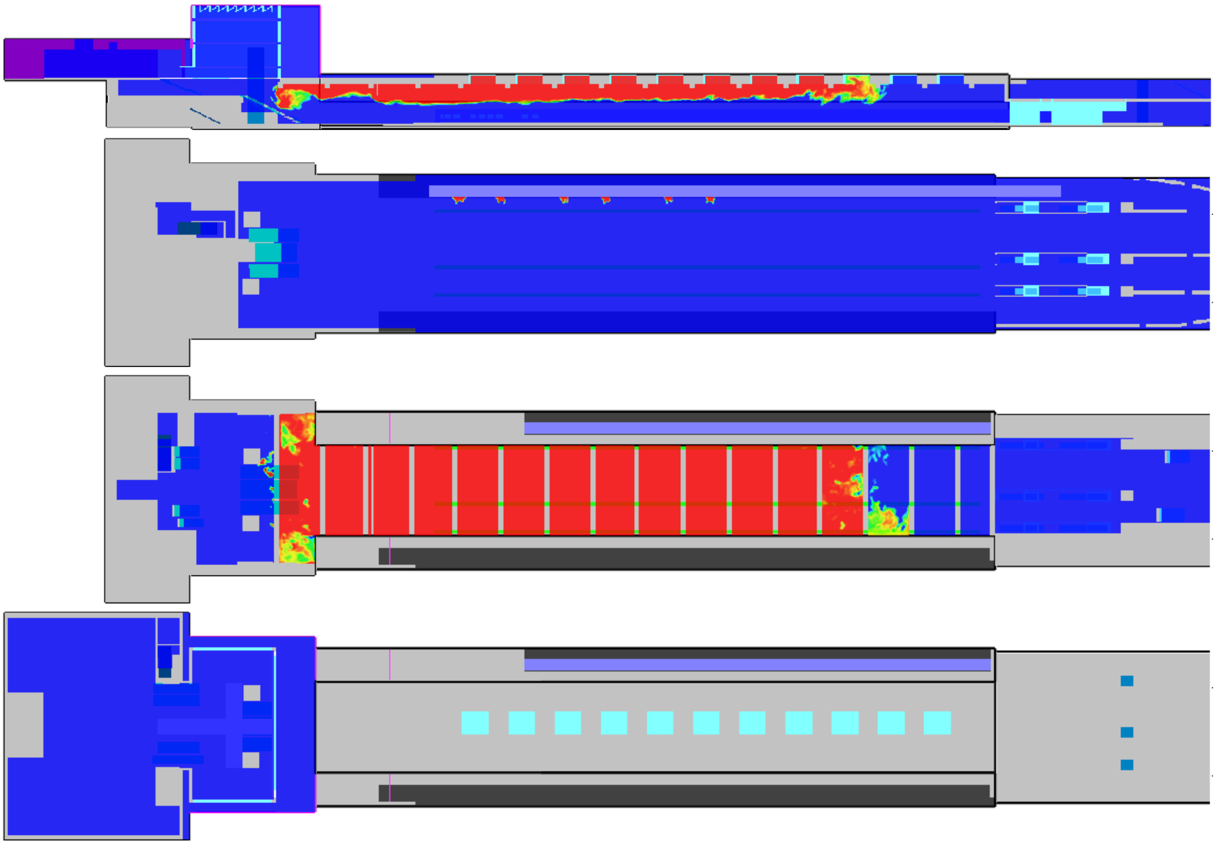


CO

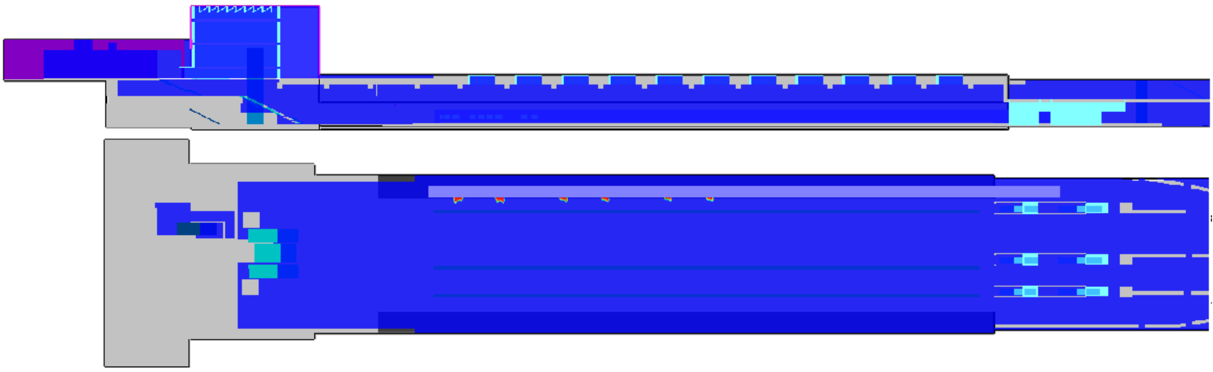


Fire Scenario 6P - Time = 240 seconds

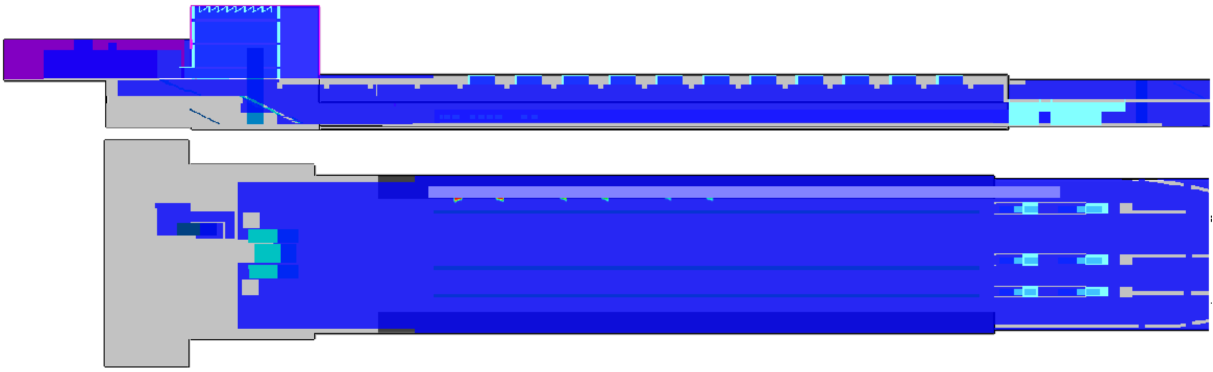
Visibility



Temperature

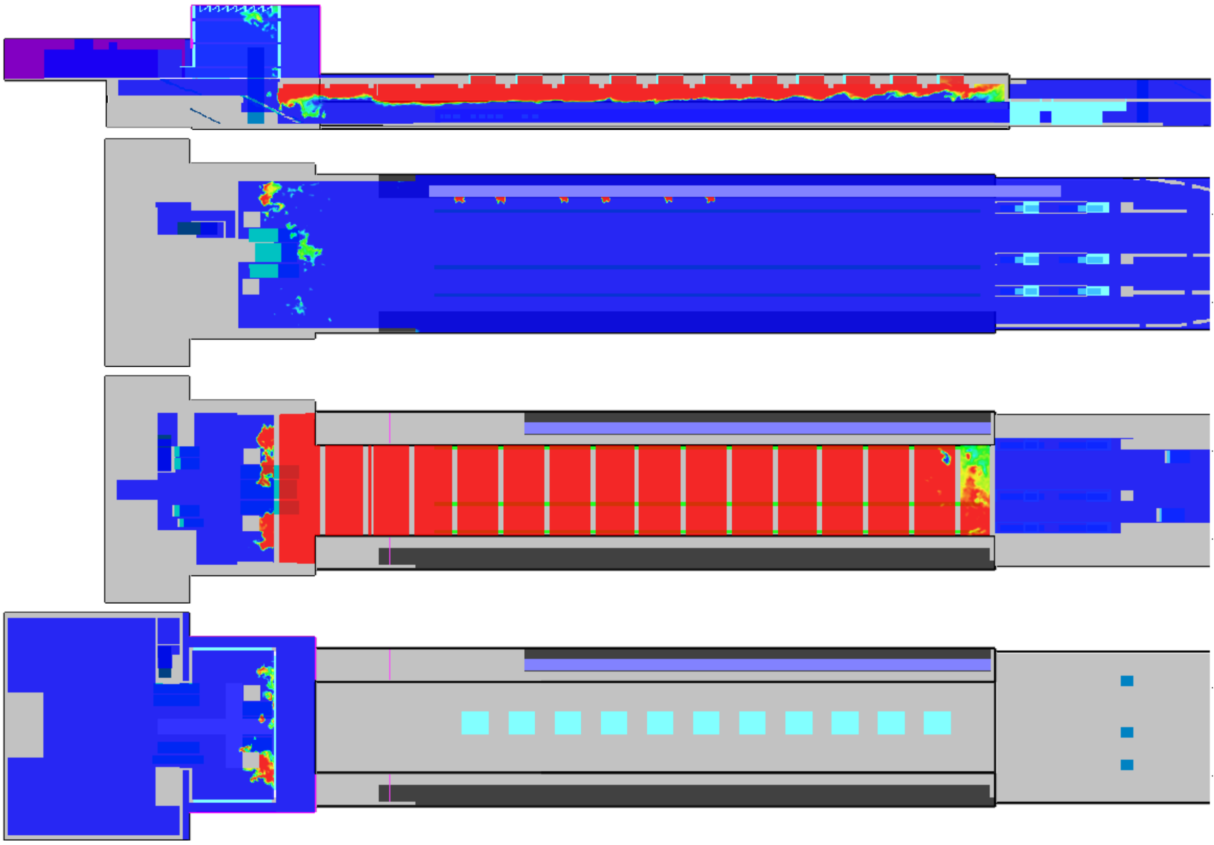


CO

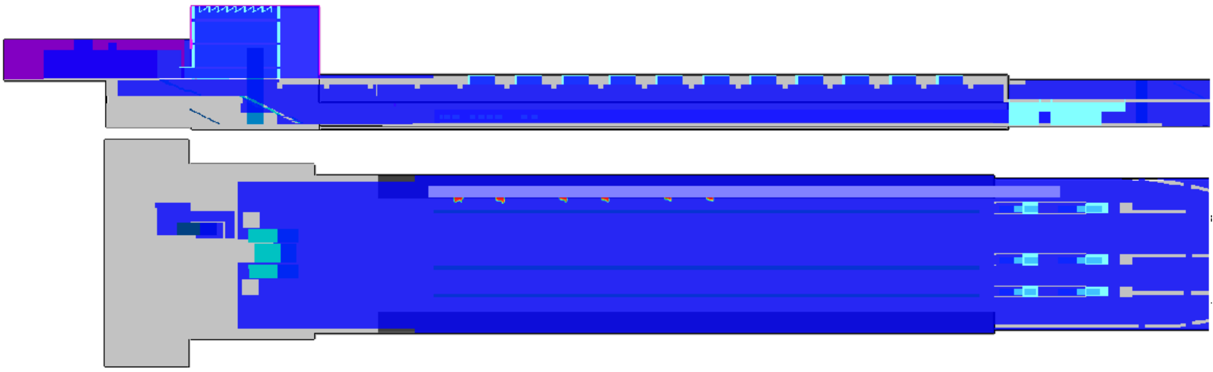


Fire Scenario 6P - Time = 360 seconds

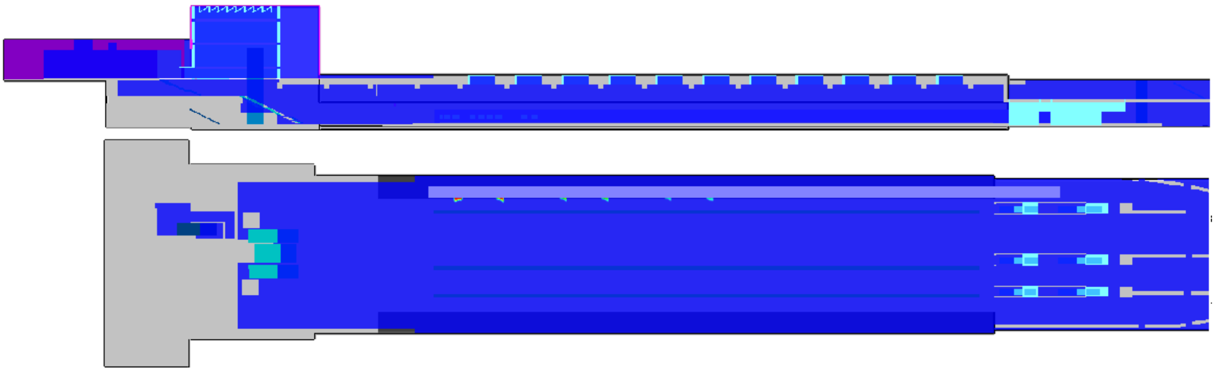
Visibility



Temperature

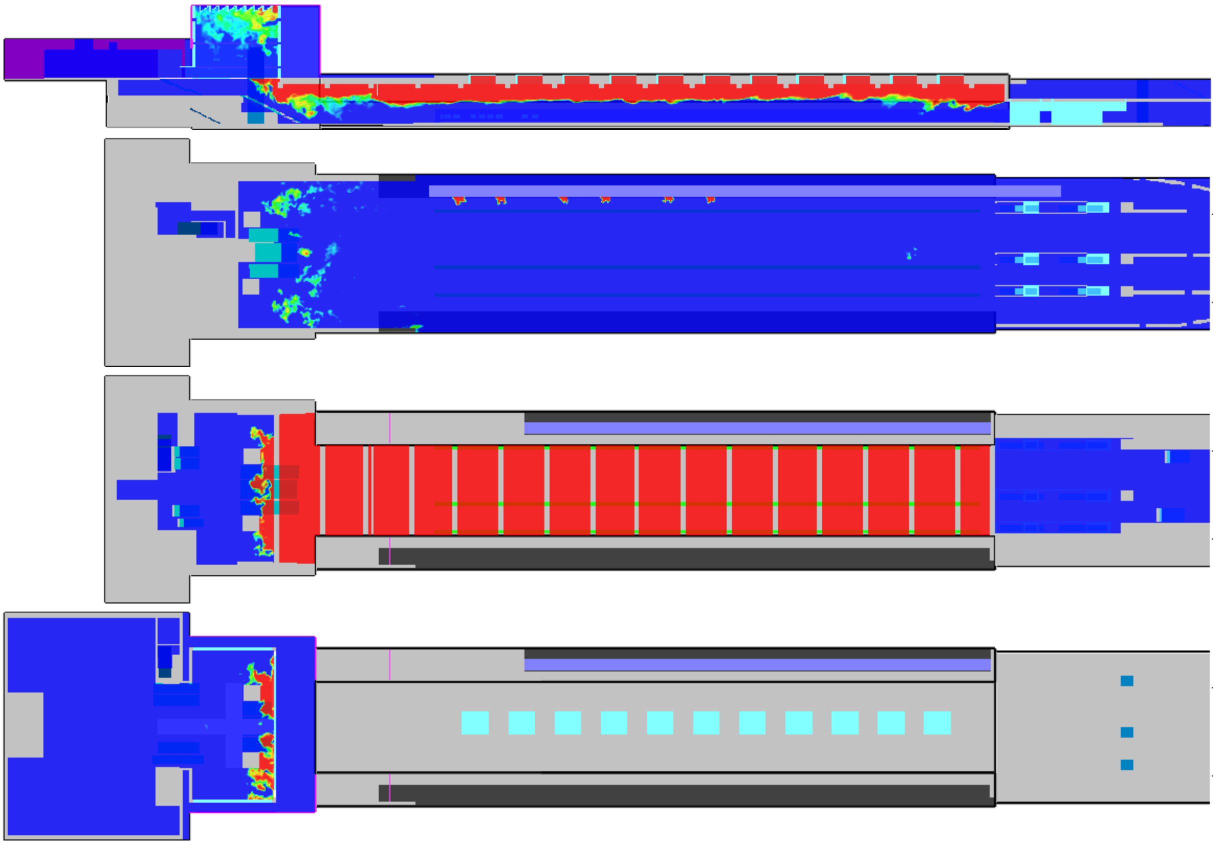


CO

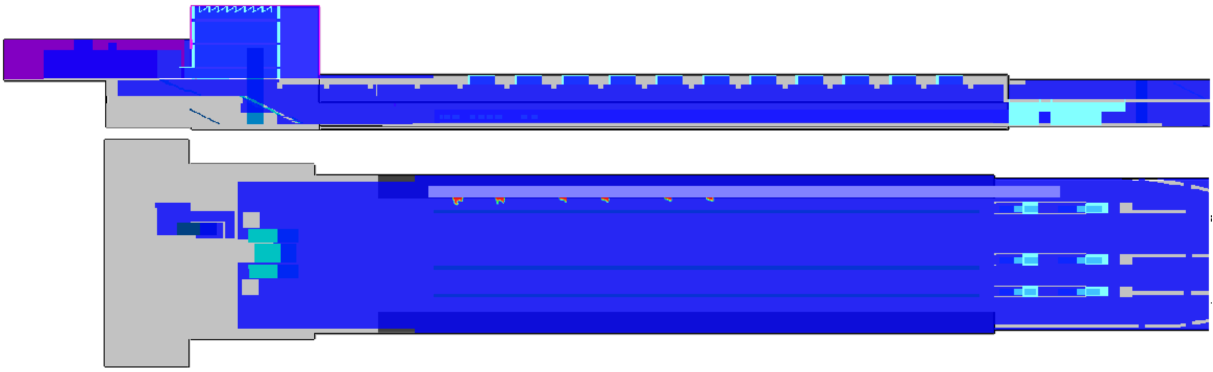


Fire Scenario 6P - Time = 480 seconds

Visibility



Temperature



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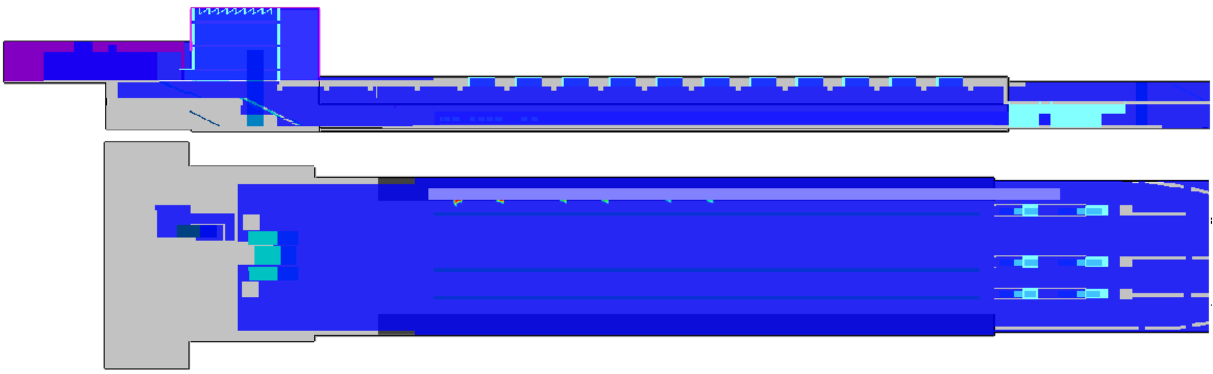
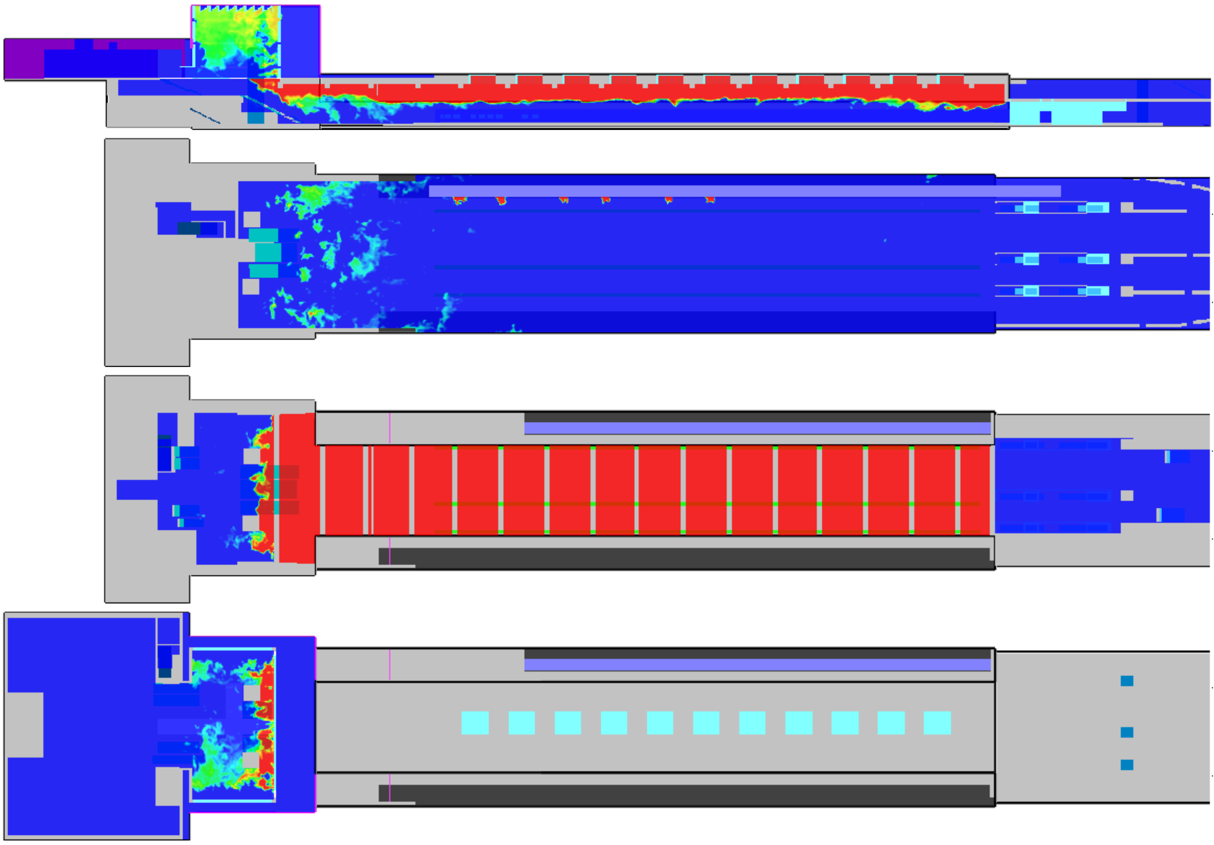
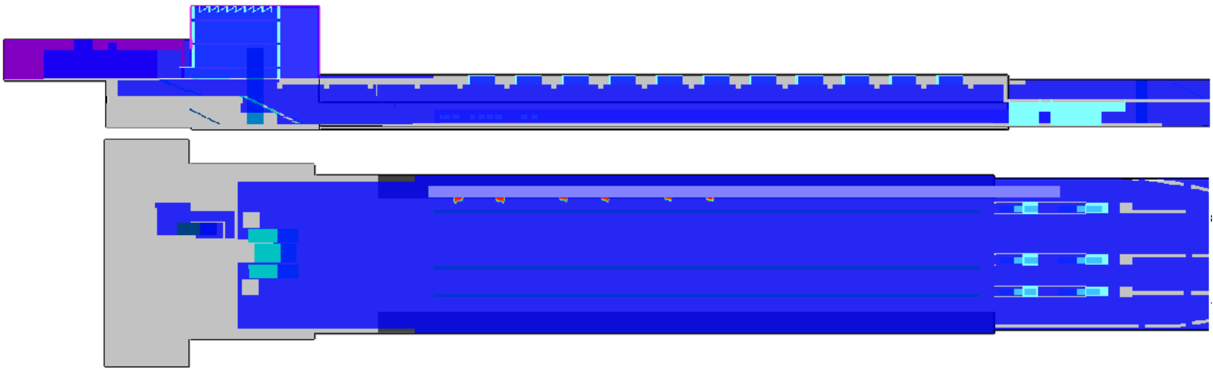


Fire Scenario 6P - Time = 600 seconds

Visibility



Temperature



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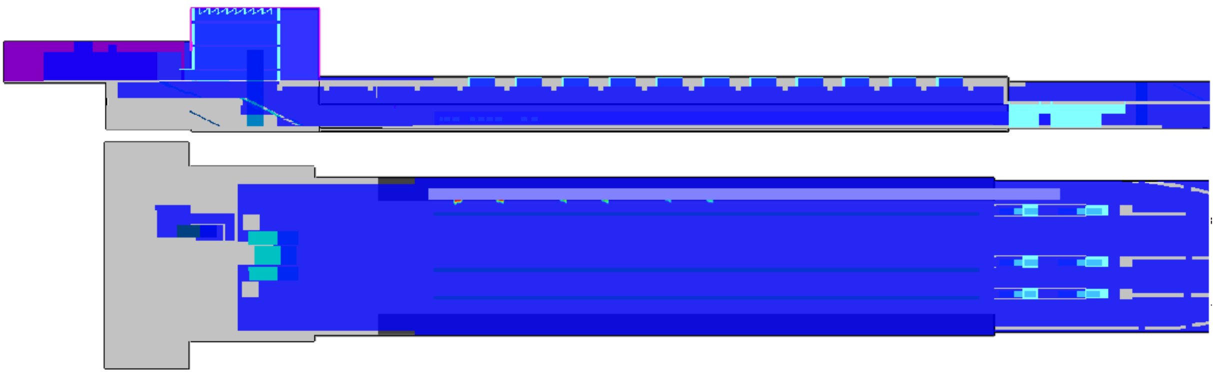
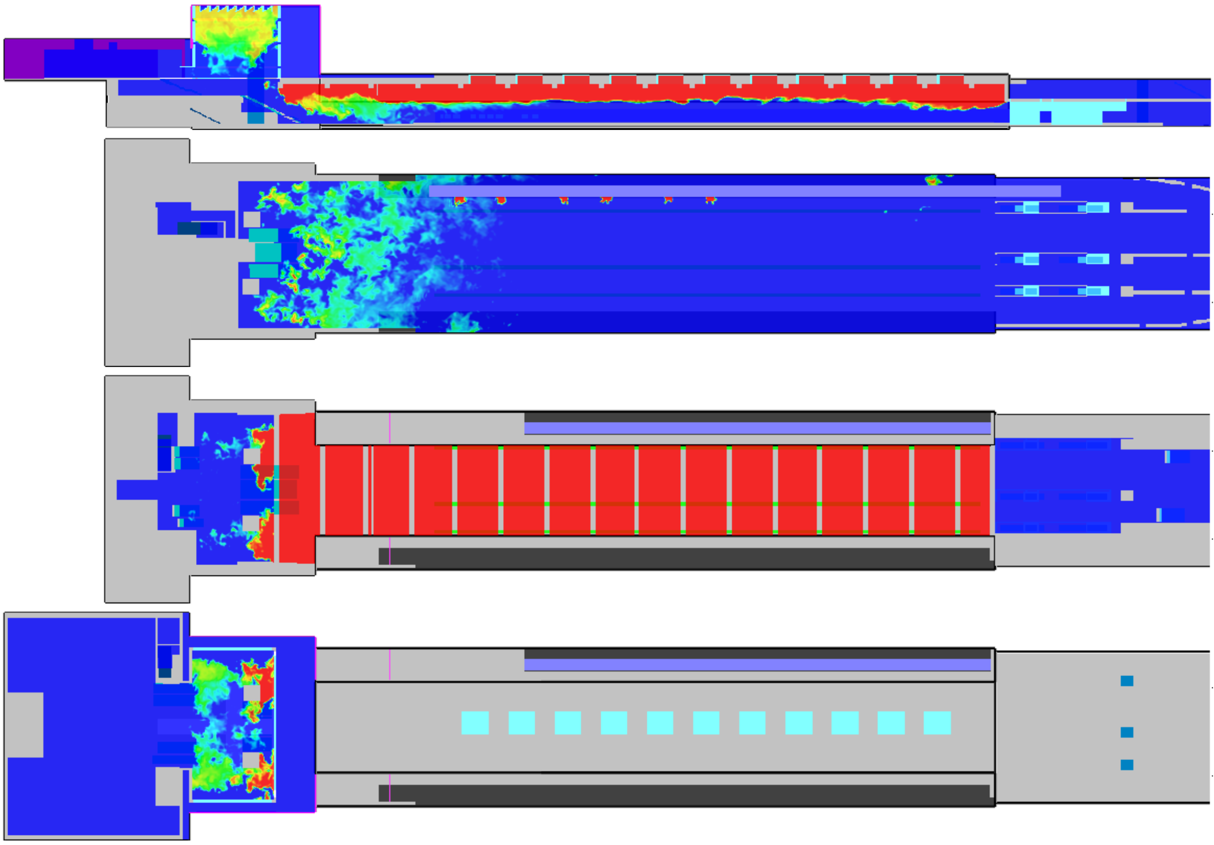
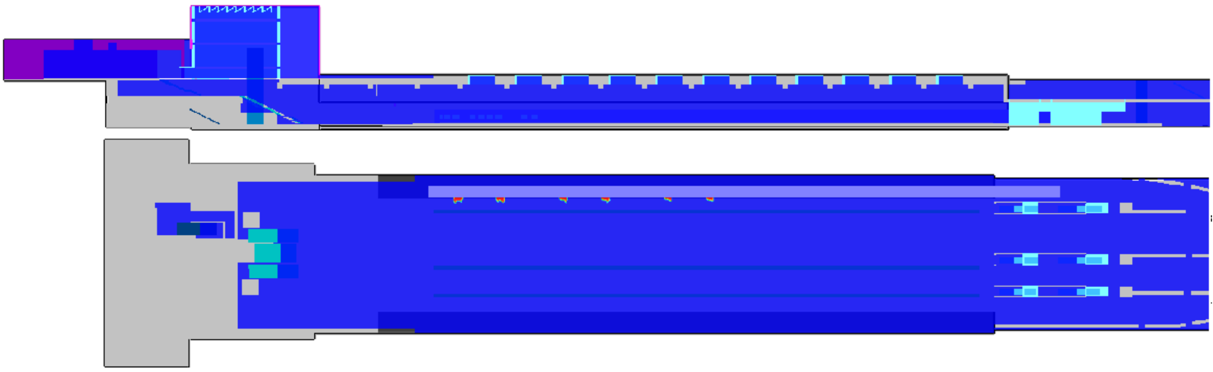


Fire Scenario 6P - Time = 720 seconds

Visibility



Temperature



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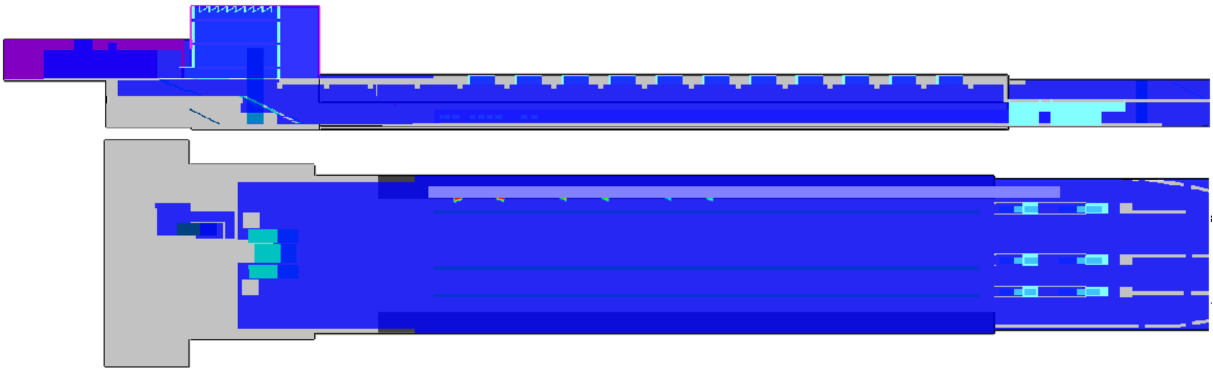
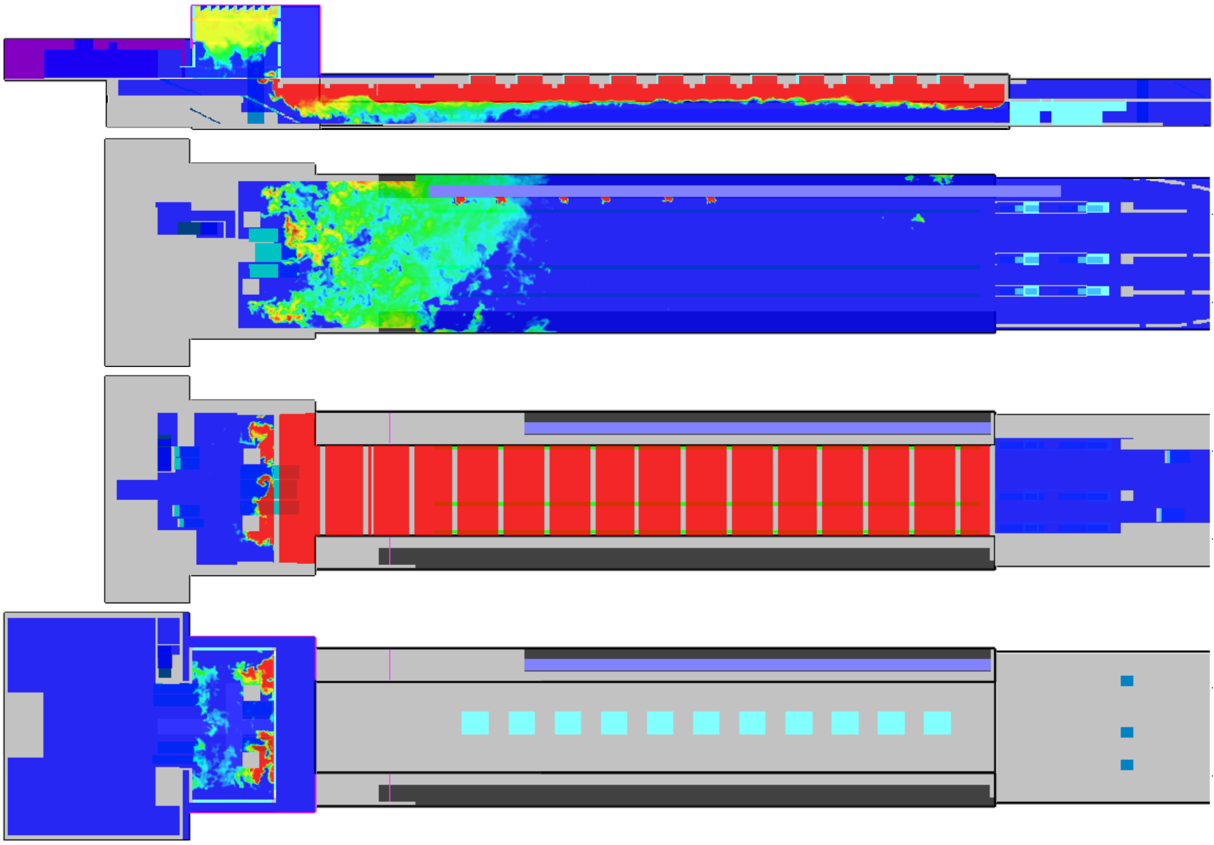
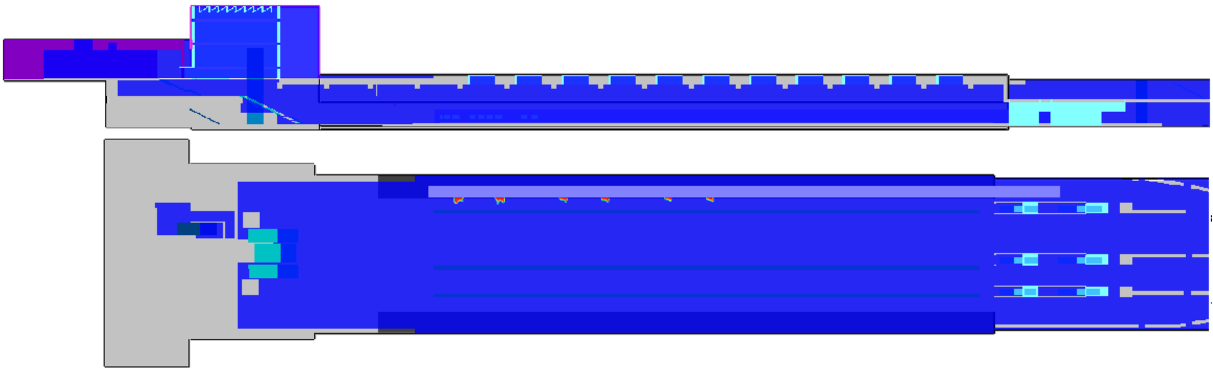


Fire Scenario 6P - Time = 840 seconds

Visibility



Temperature



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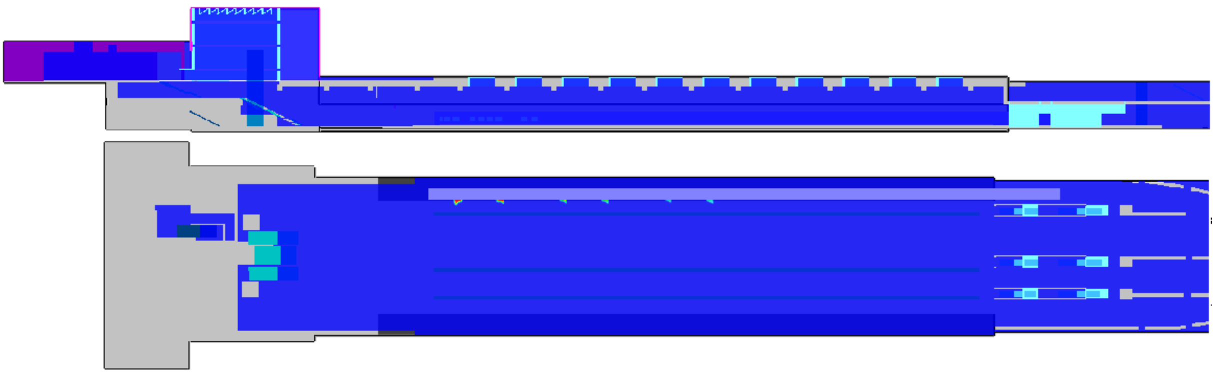
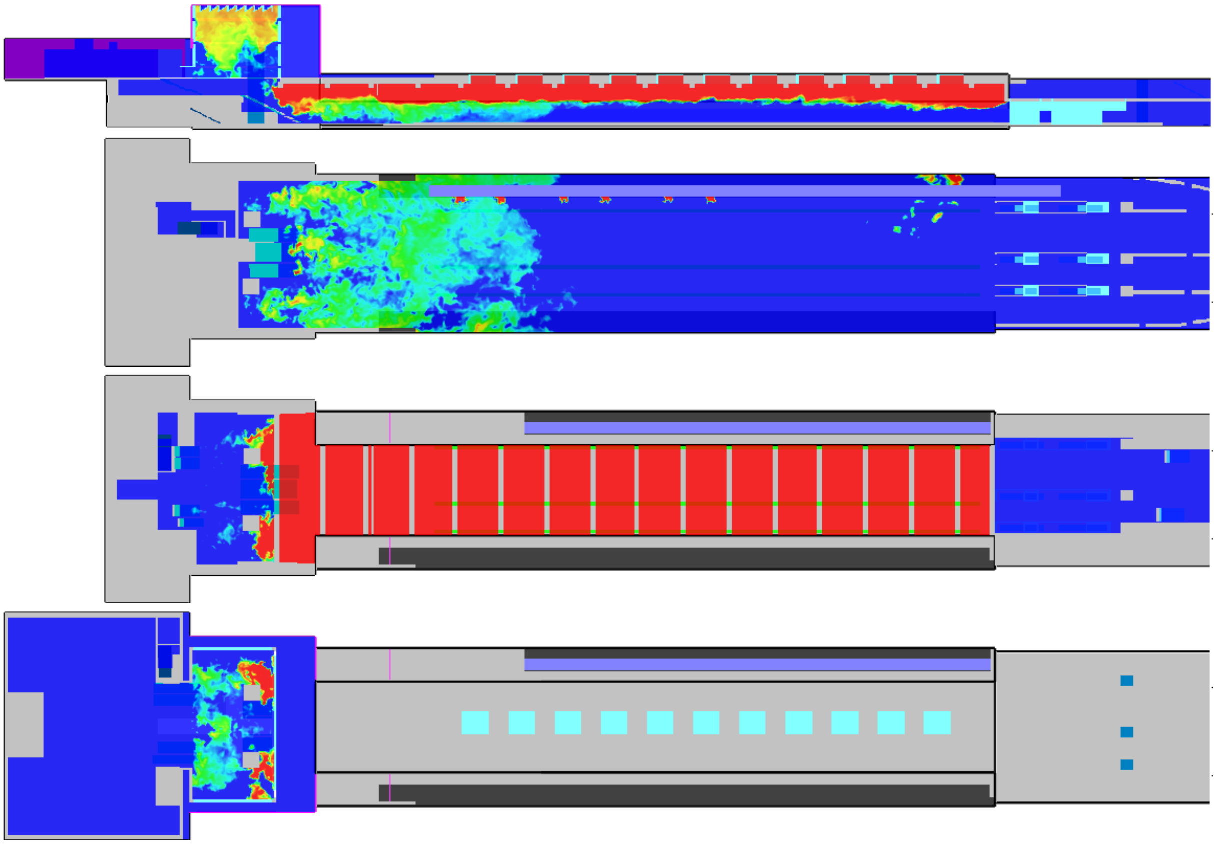
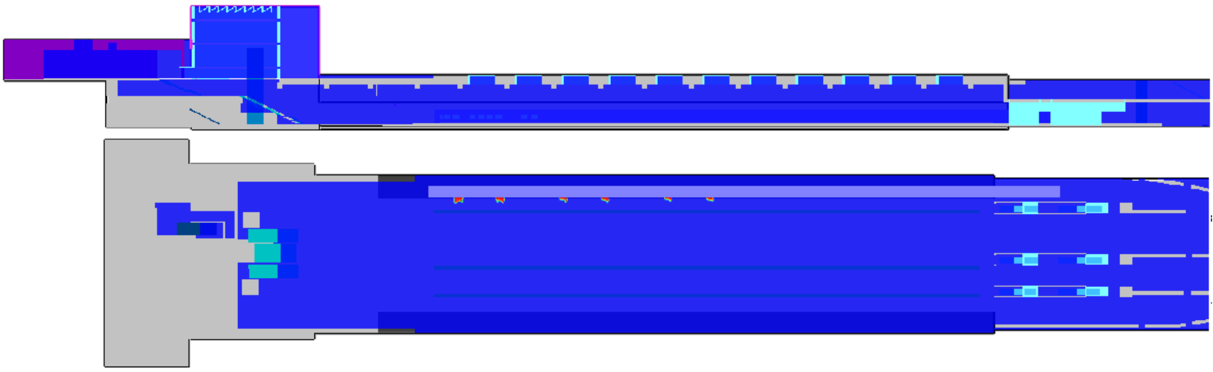


Fire Scenario 6P - Time = 960 seconds

Visibility



Temperature



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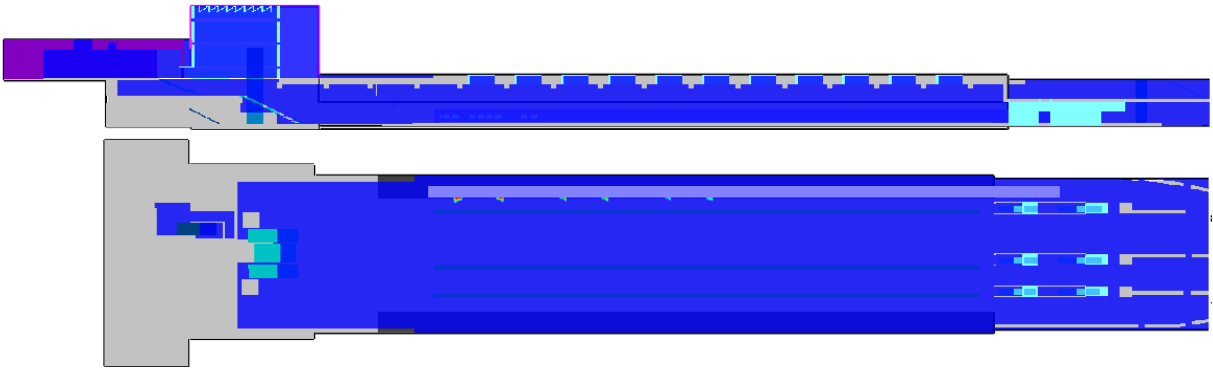
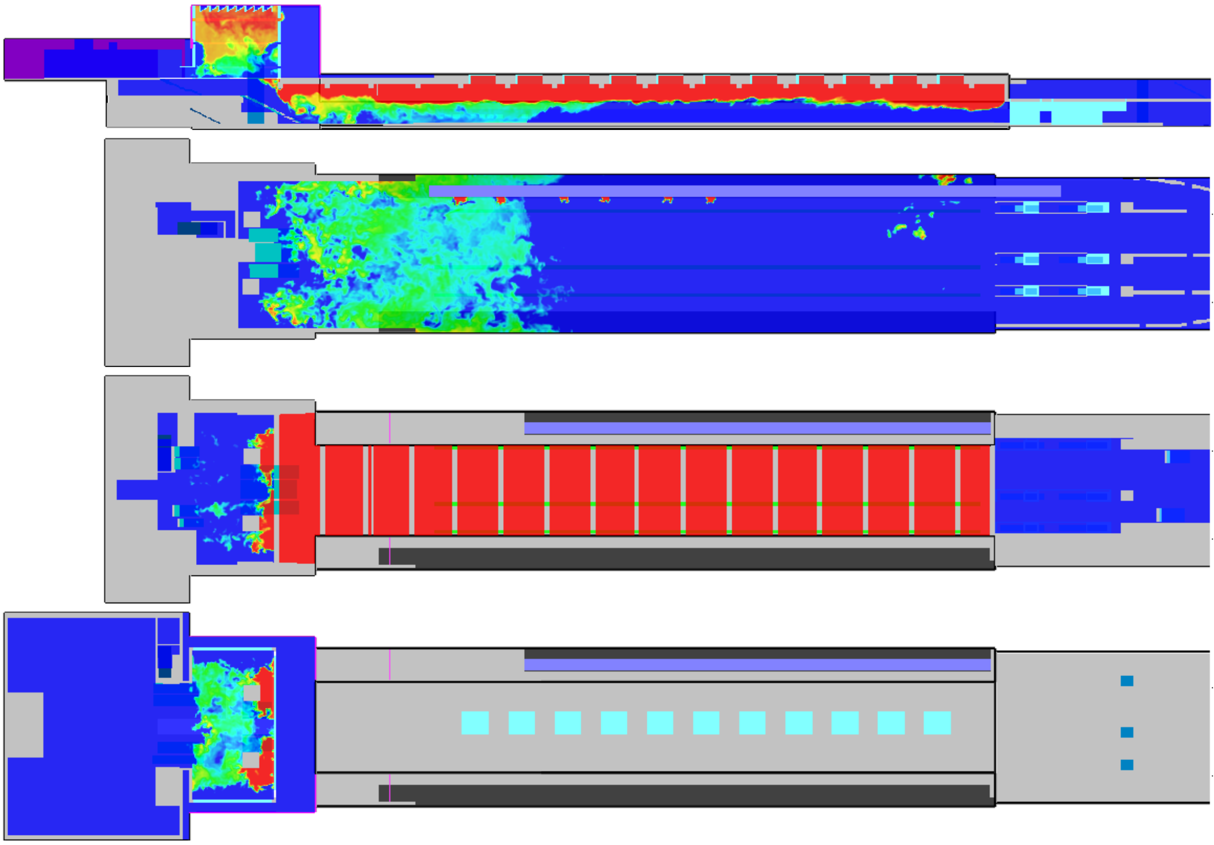
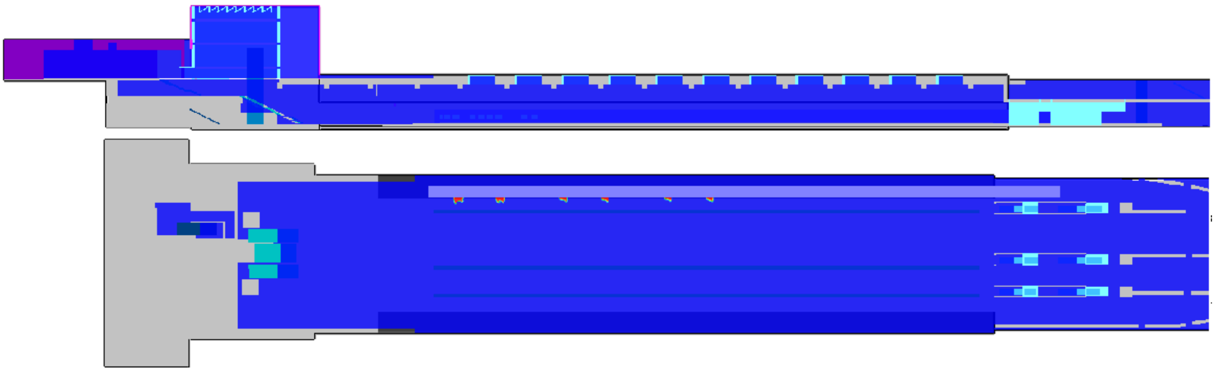


Fire Scenario 6P - Time = 1,200 seconds

Visibility



Temperature



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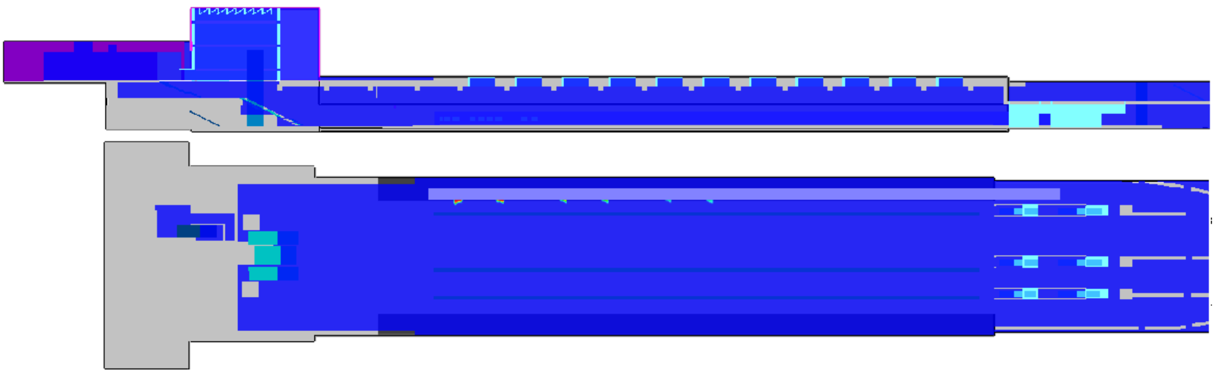
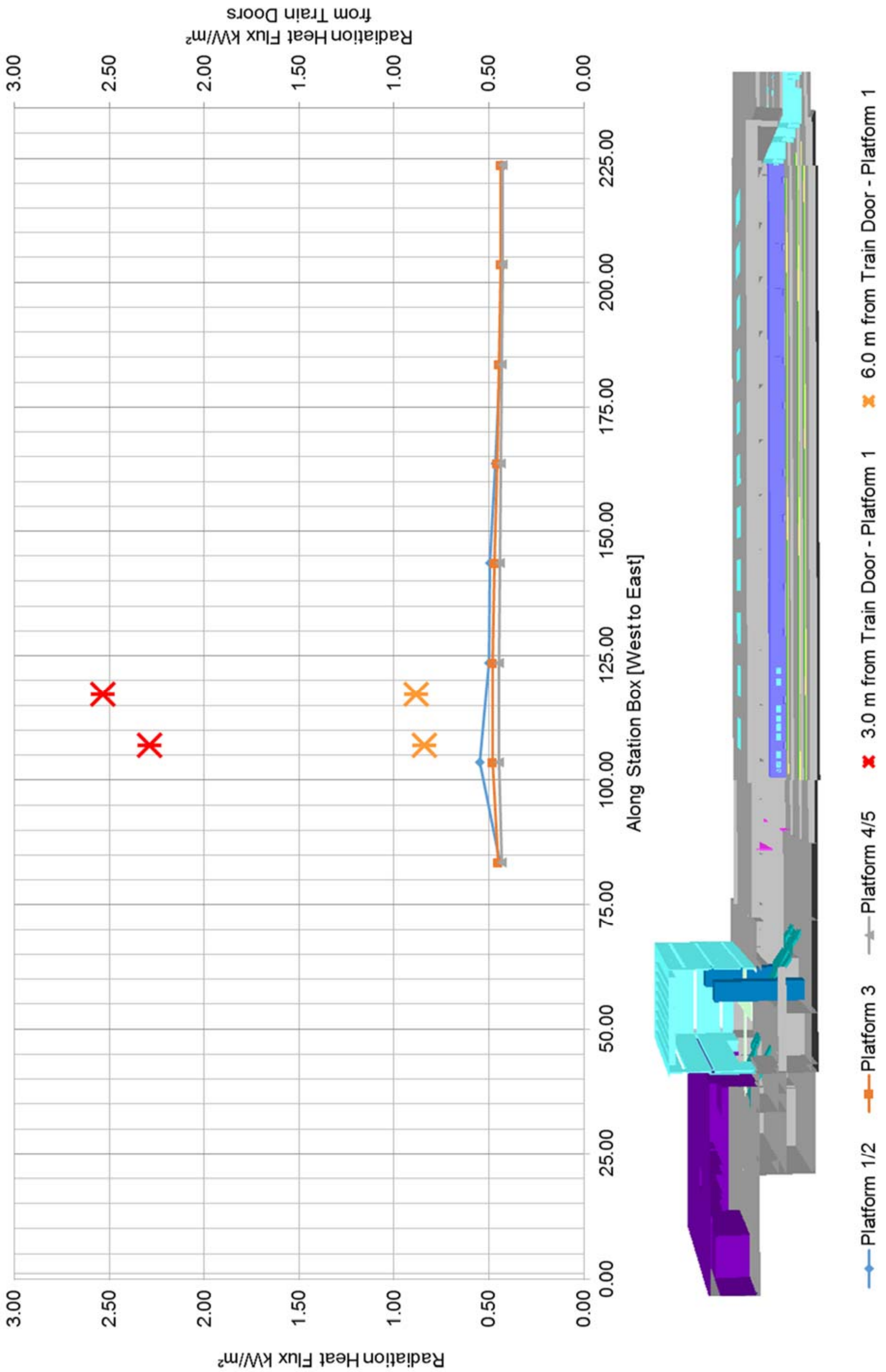
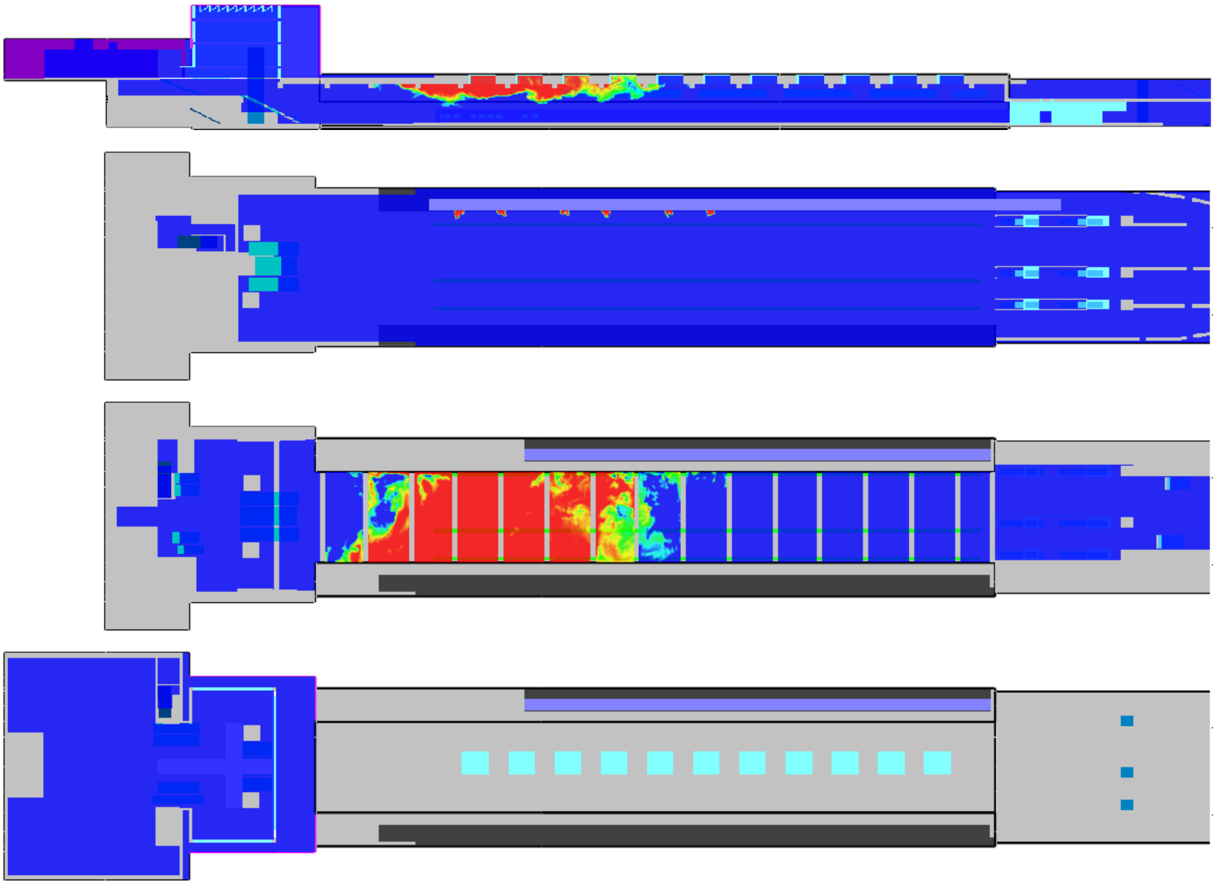


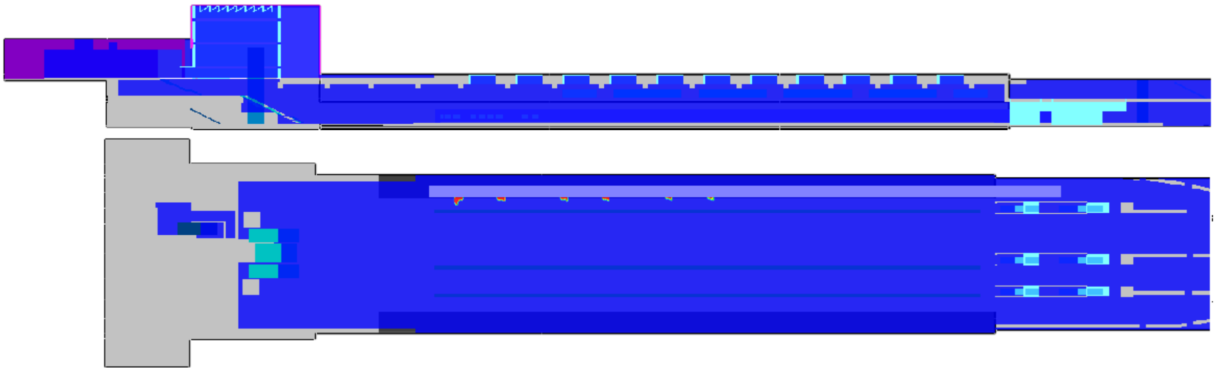

Radiation Heat Flux kW/m²
from Train Doors
Radiation Heat Flux kW/m²
Along Station Box [West to East]
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Platform 1/2
Platform 3
Platform 4/5
3.0 m from Train Door - Platform 1
6.0 m from Train Door - Platform 1

Fire Scenario 7P - Time = 120 seconds

Visibility



Temperature



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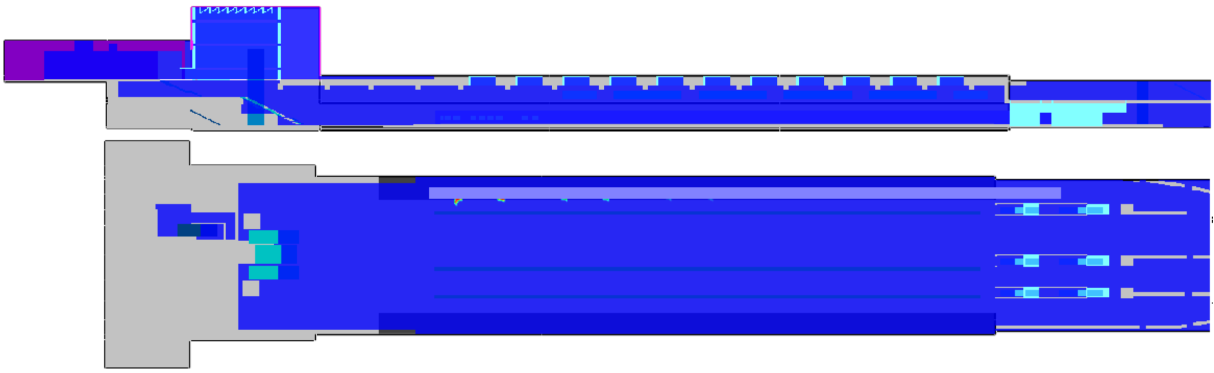
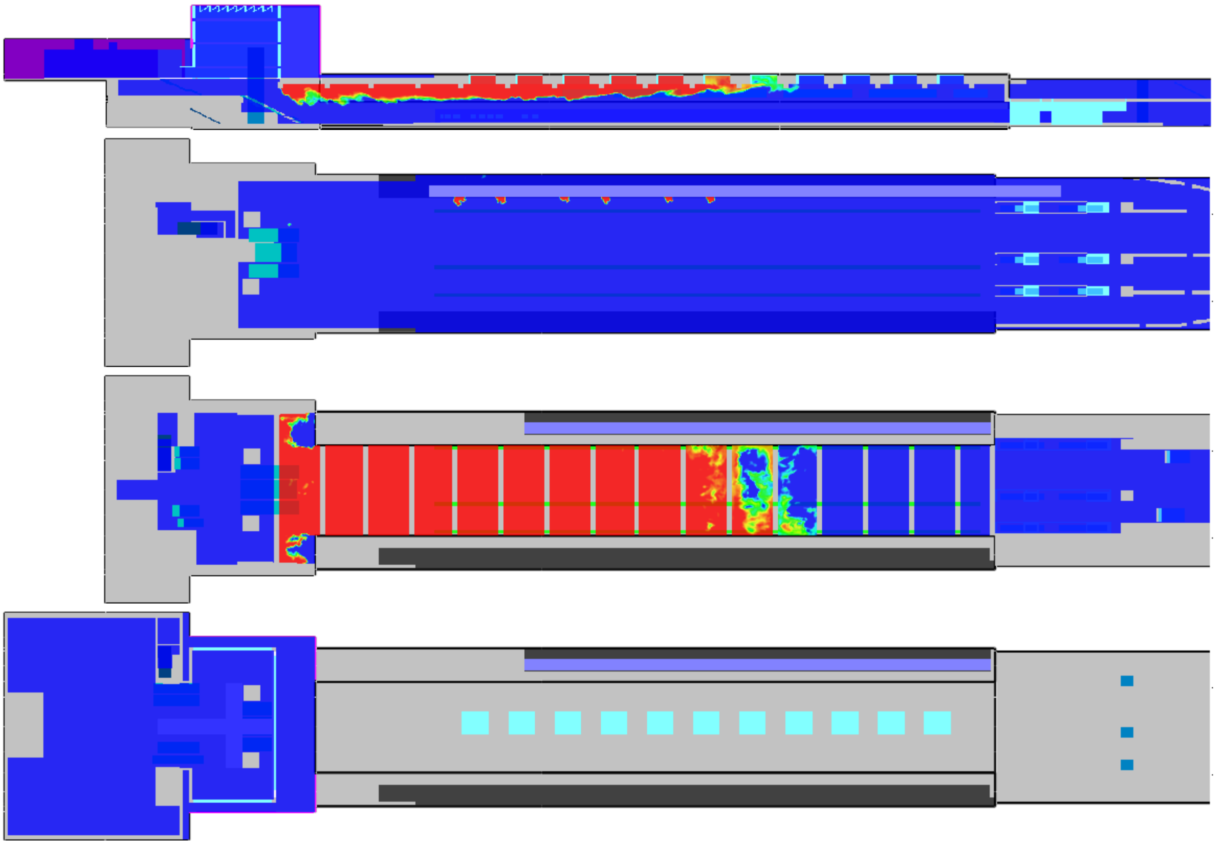
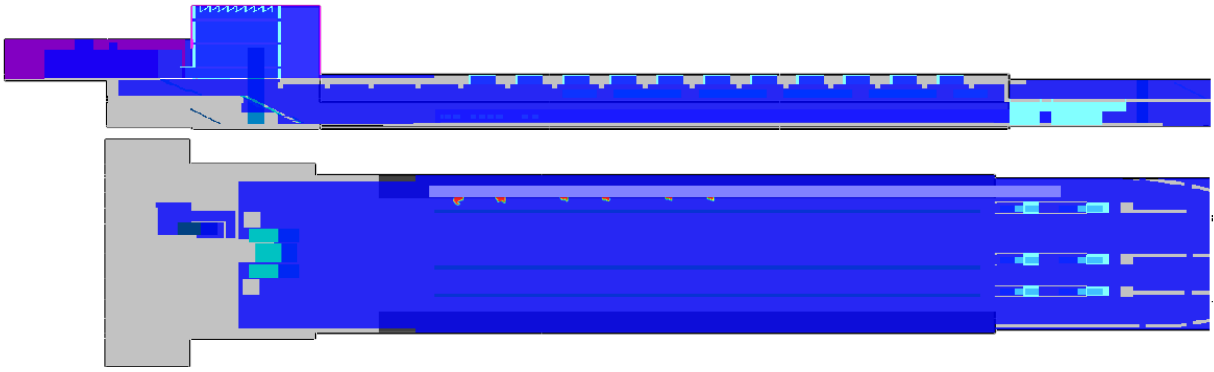


Fire Scenario 7P - Time = 240 seconds

Visibility



Temperature



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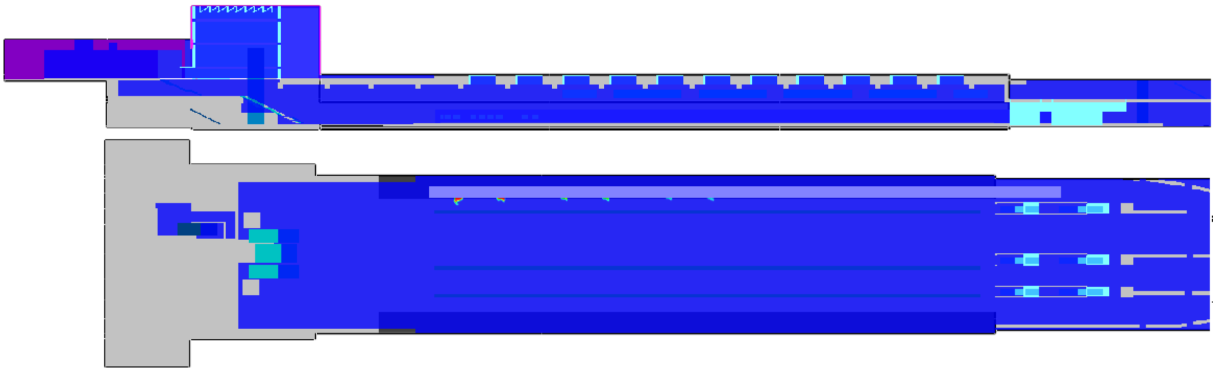
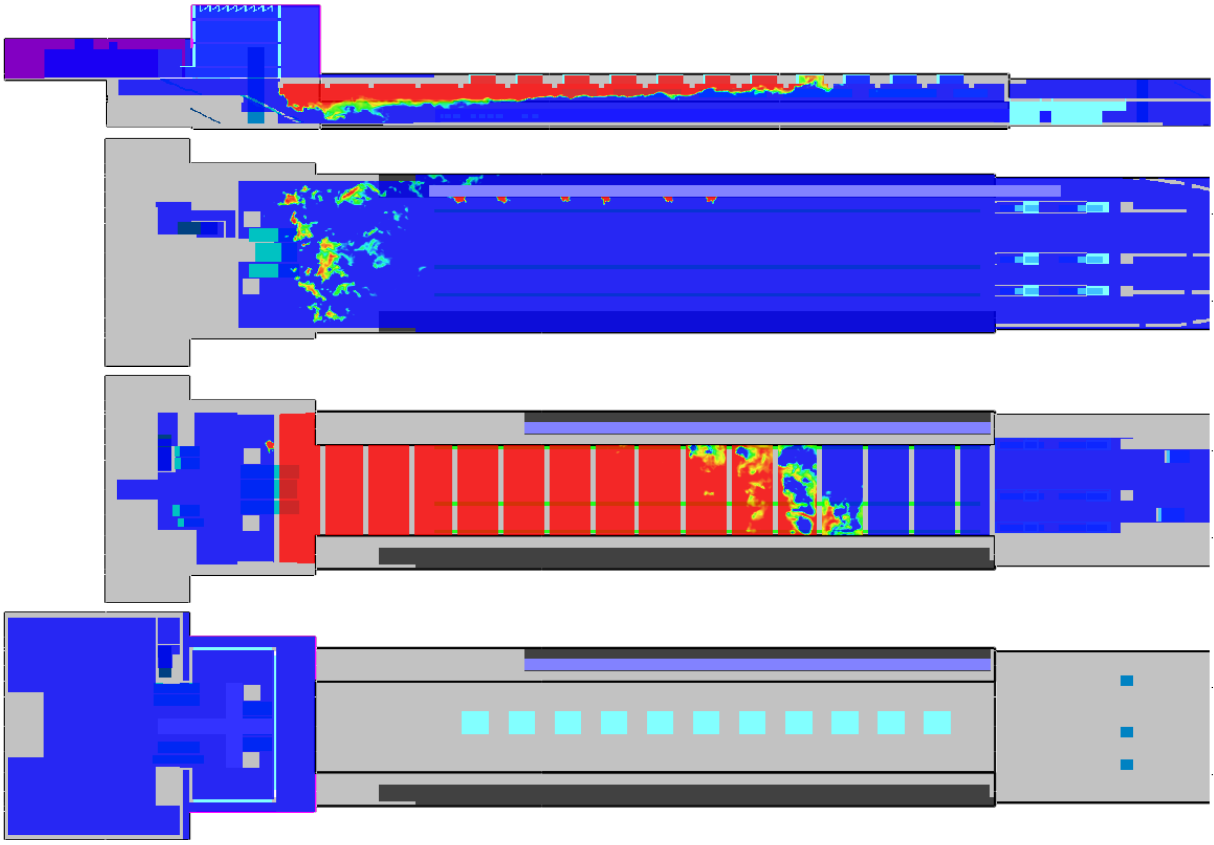
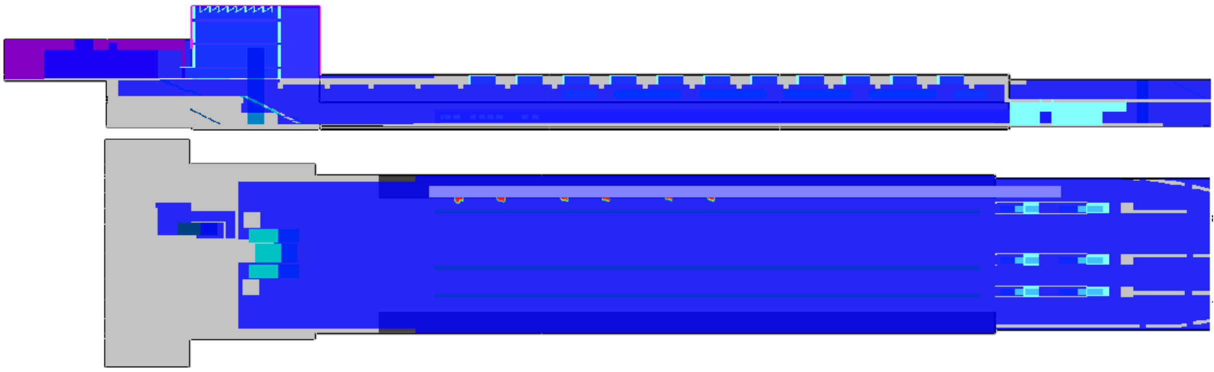


Fire Scenario 7P - Time = 360 seconds

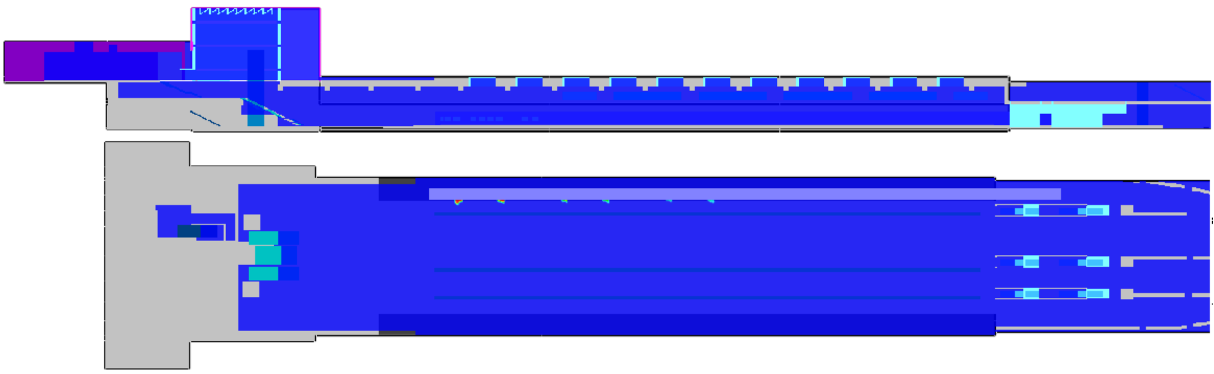
Visibility



Temperature

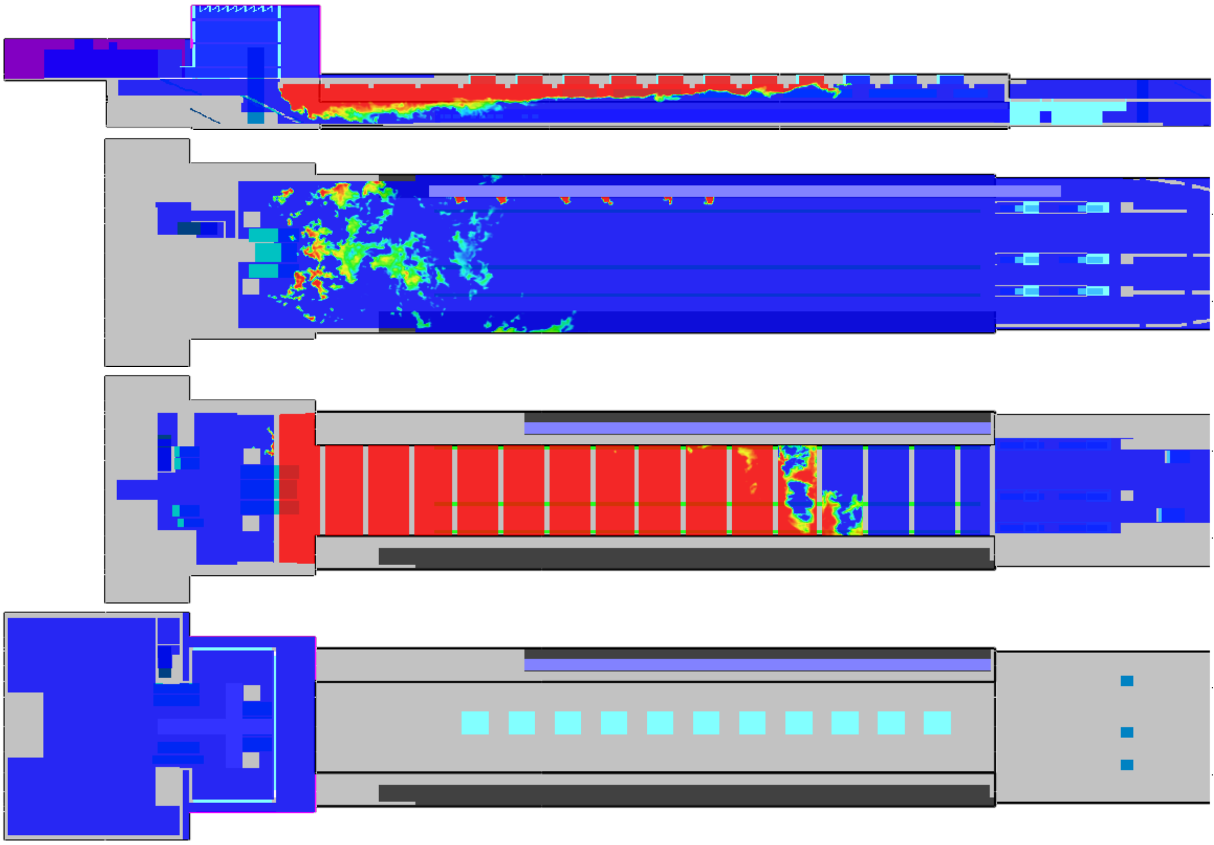


CO

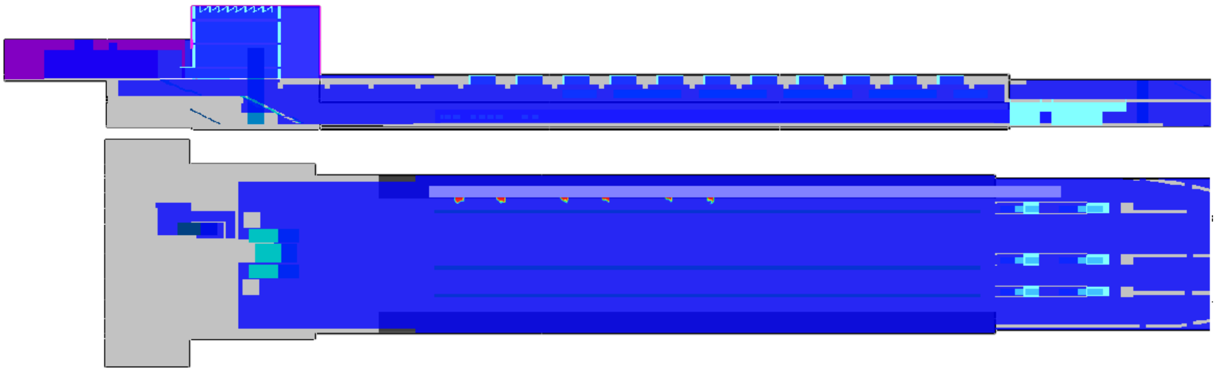


Fire Scenario 7P - Time = 480 seconds

Visibility



Temperature



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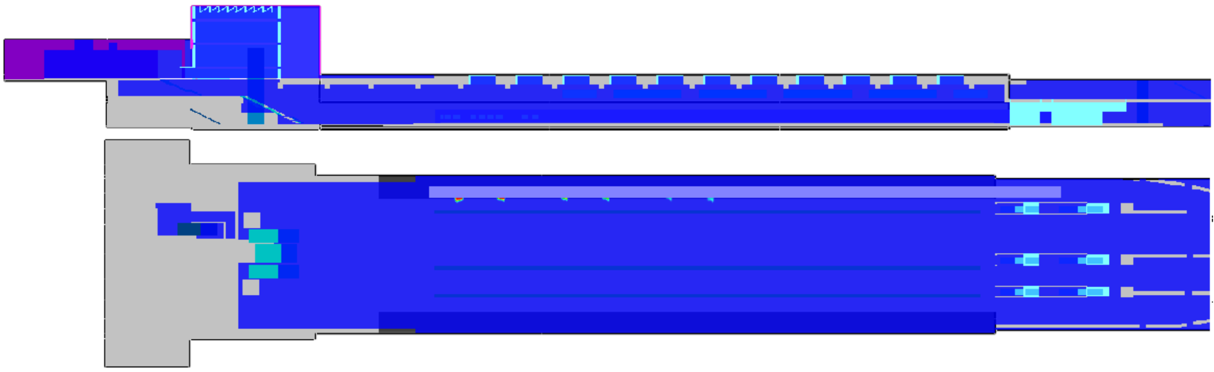
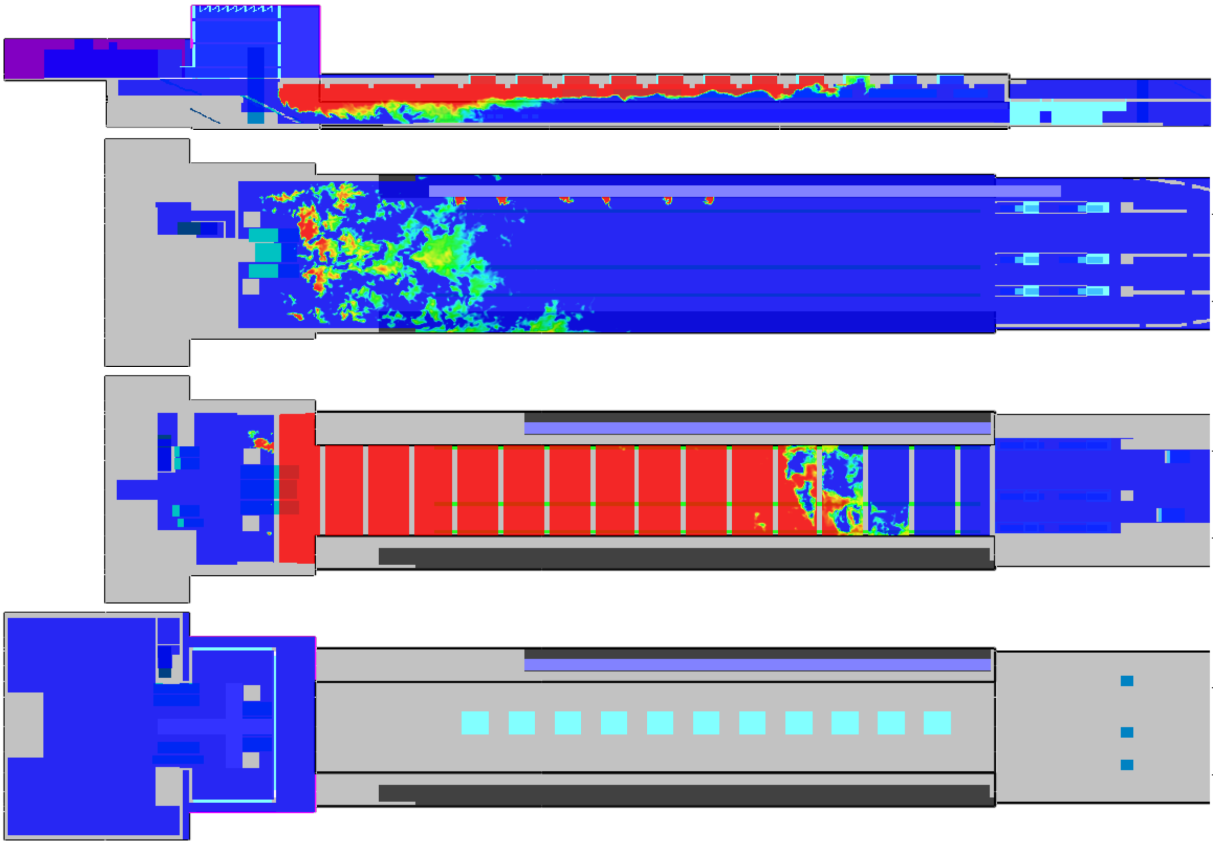
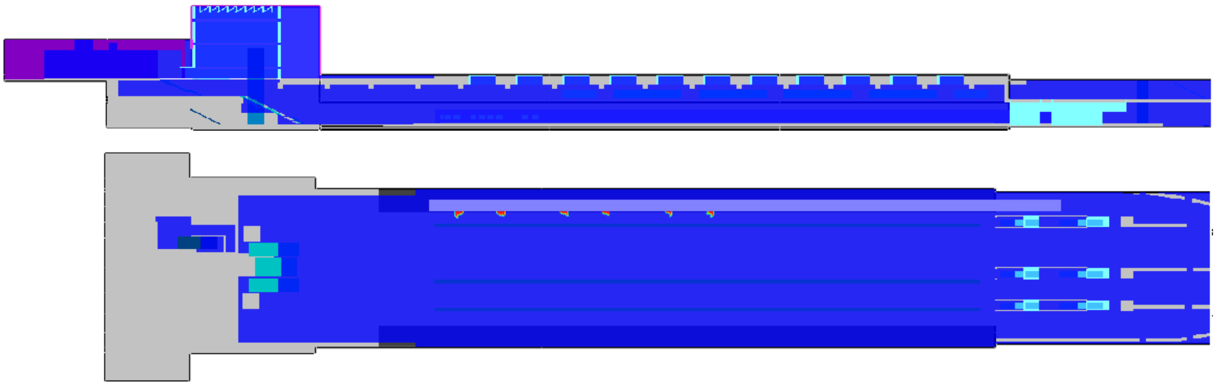


Fire Scenario 7P - Time = 600 seconds

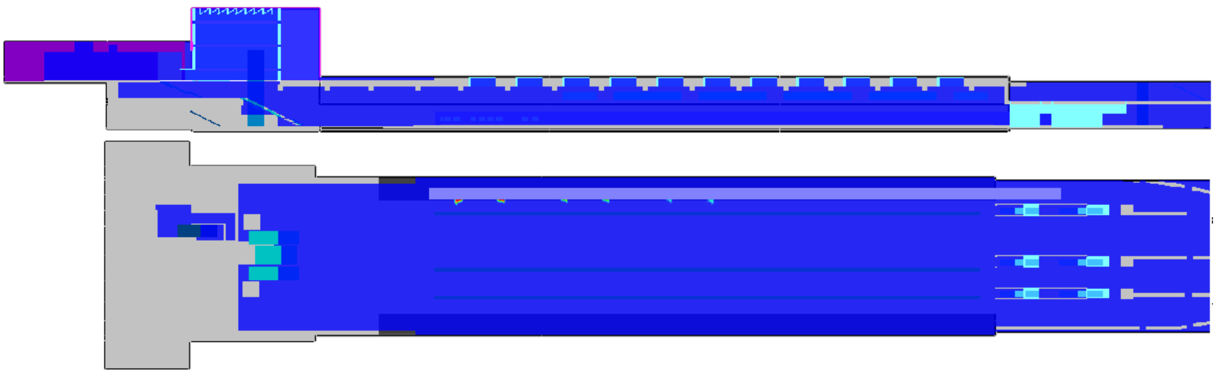
Visibility



Temperature

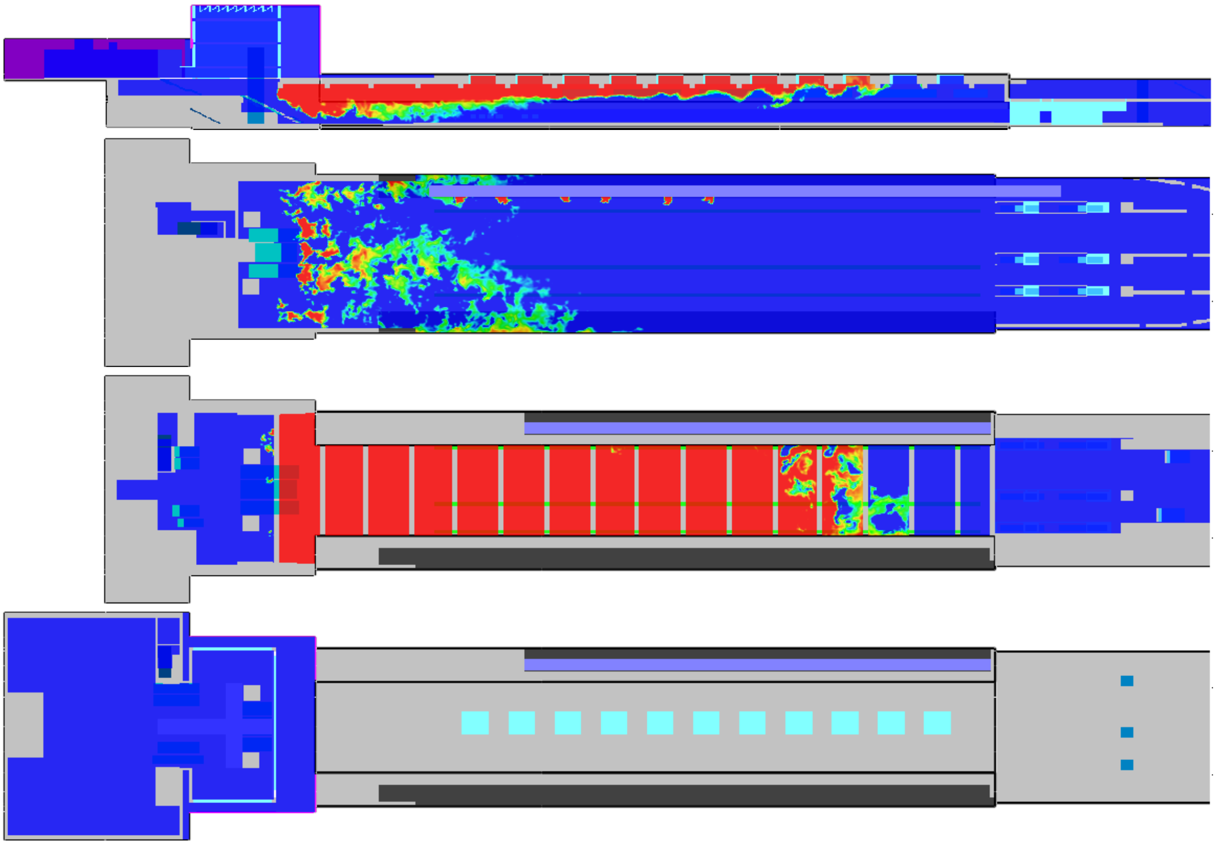


CO

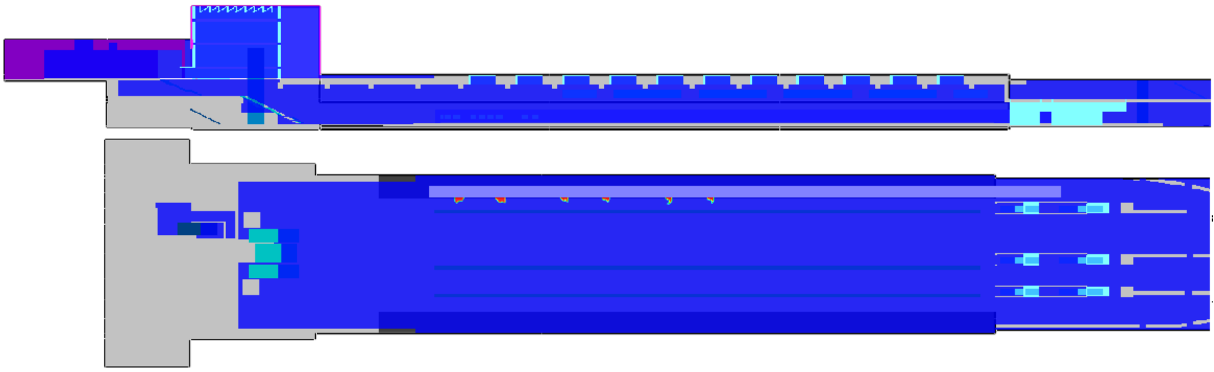


Fire Scenario 7P - Time = 720 seconds

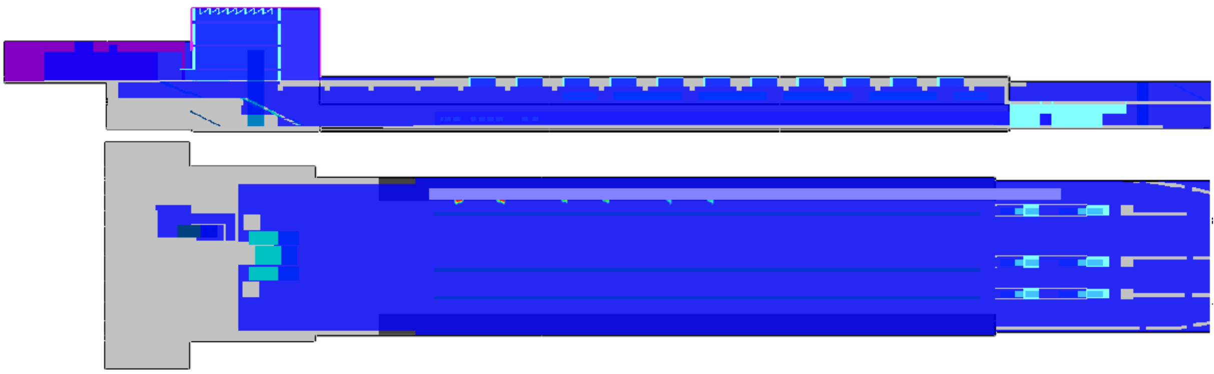
Visibility



Temperature

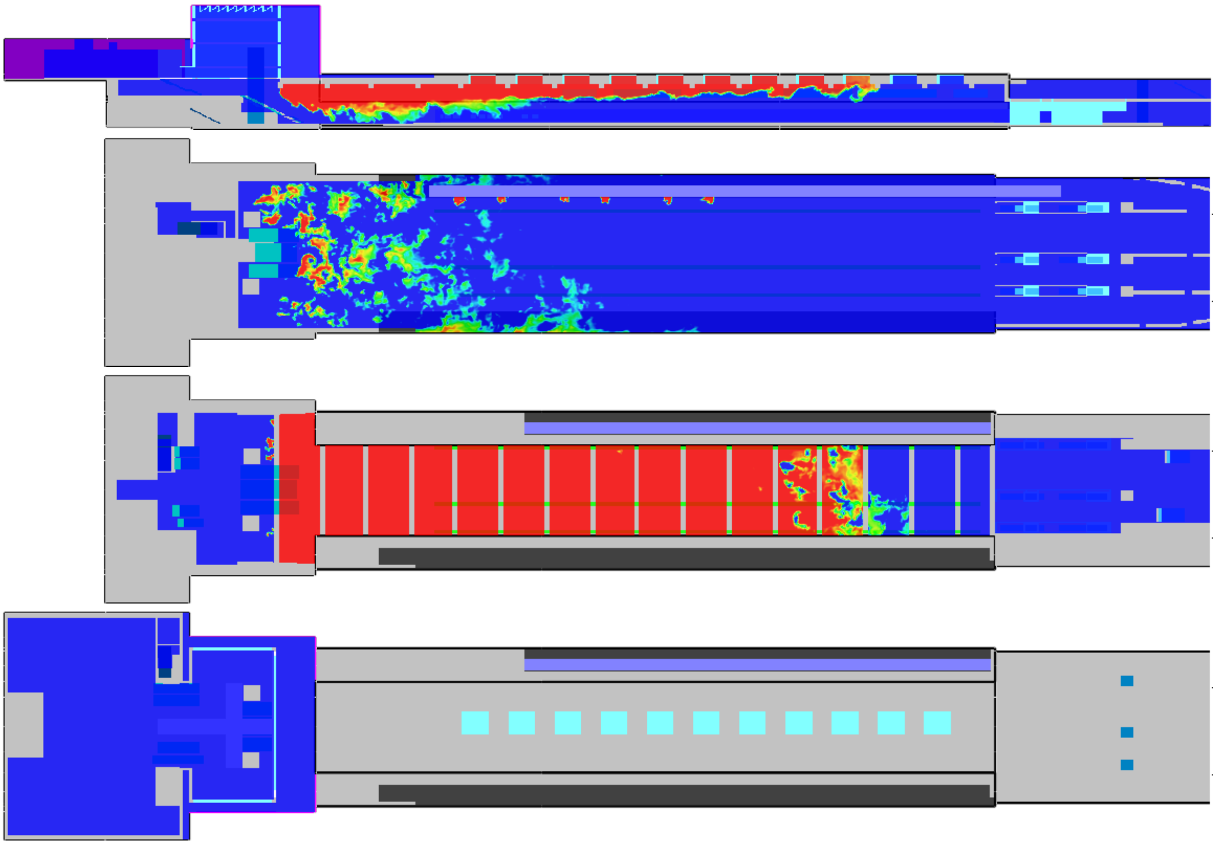


CO

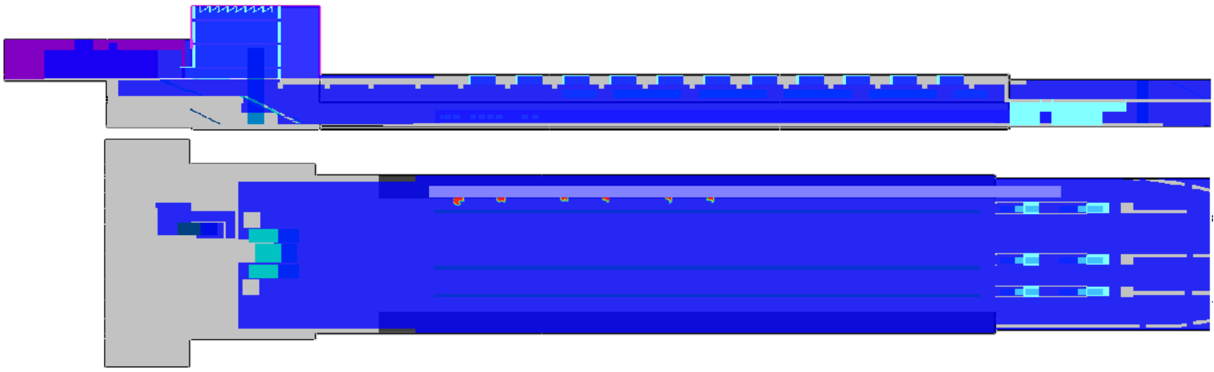


Fire Scenario 7P - Time = 840 seconds

Visibility



Temperature



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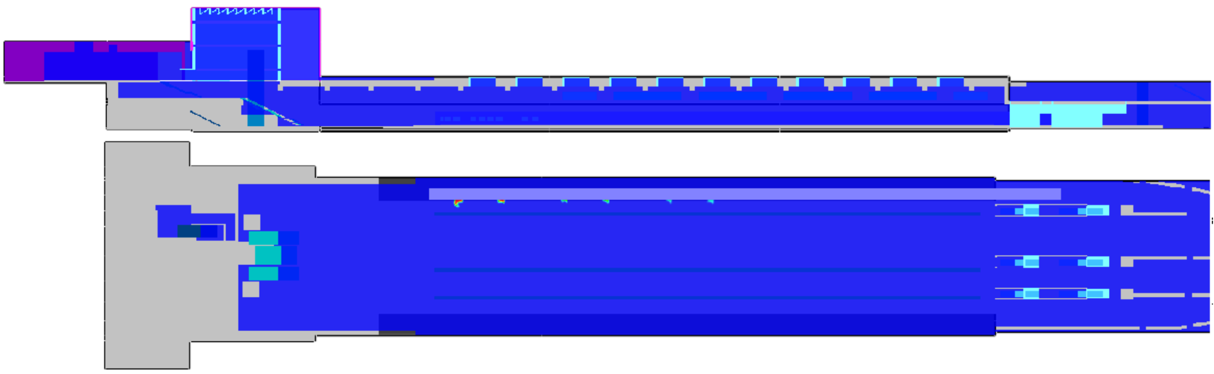
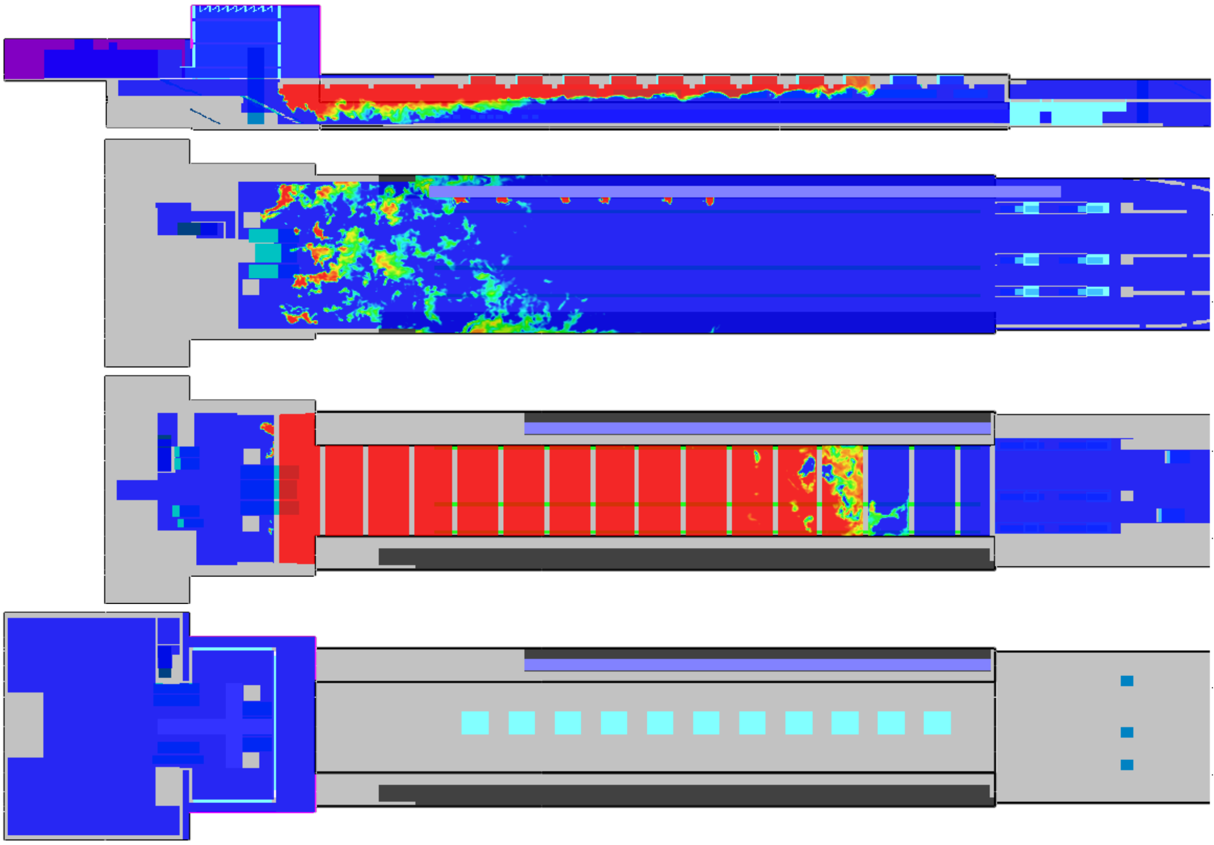
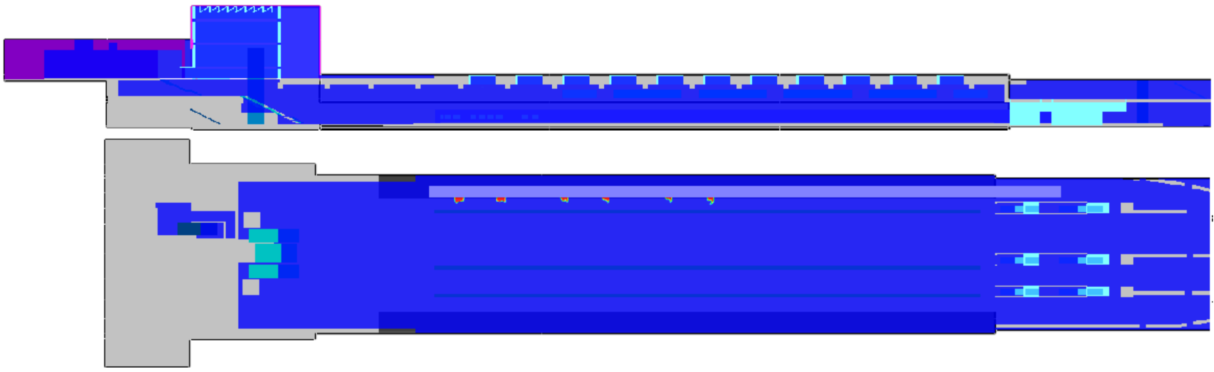


Fire Scenario 7P - Time = 852 seconds

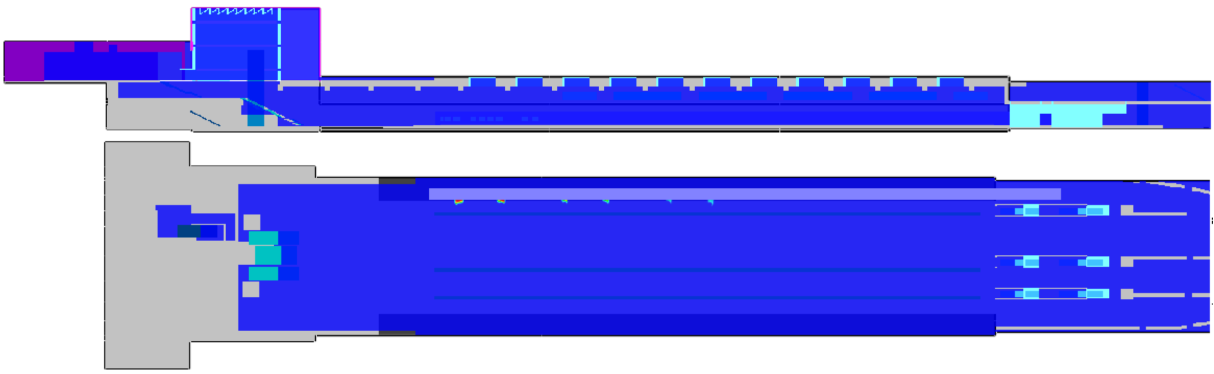
Visibility

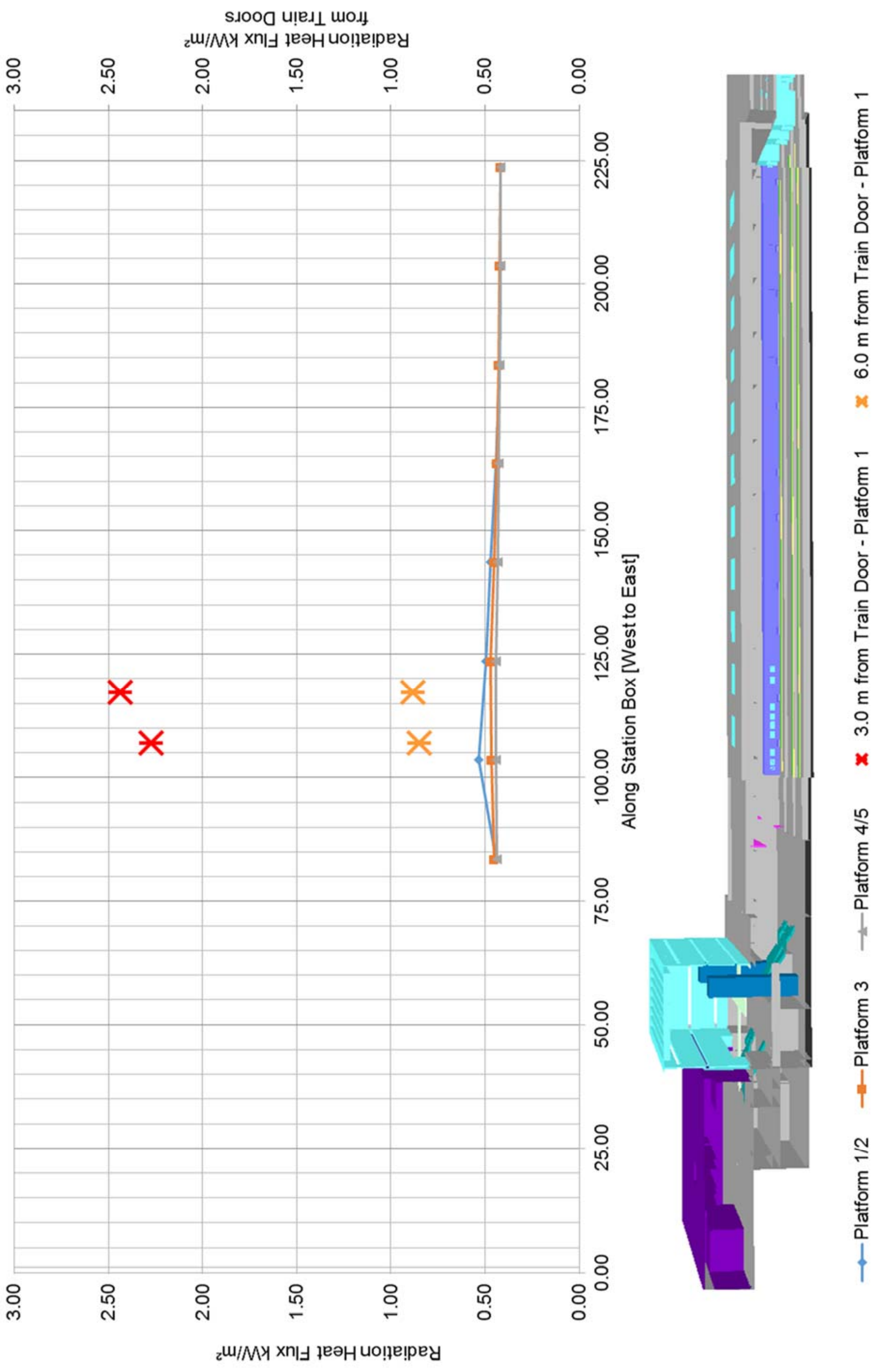


Temperature



CO




Radiation Heat Flux kW/m²
Radiation Heat Flux kW/m² from Train Doors
Along Station Box [West to East]
0.00
25.00
50.00
75.00
100.00
125.00
150.00
175.00
200.00
225.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Platform 1/2
Platform 3
Platform 4/5
3.0 m from Train Door - Platform 1
6.0 m from Train Door - Platform 1

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Appendix J
CPO FDS Results

Fire Models

Fire Scenario	Run ID	Location	Design Fires	Case
CPO	CPO	Centre of circulation area	Fast t^2 sprinkler controlled	Base Case

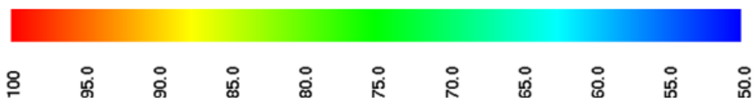
Legend

<u>Data bounds</u>

Visibility

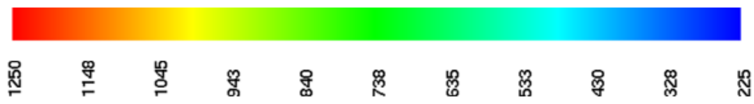
m

Temperature



°C

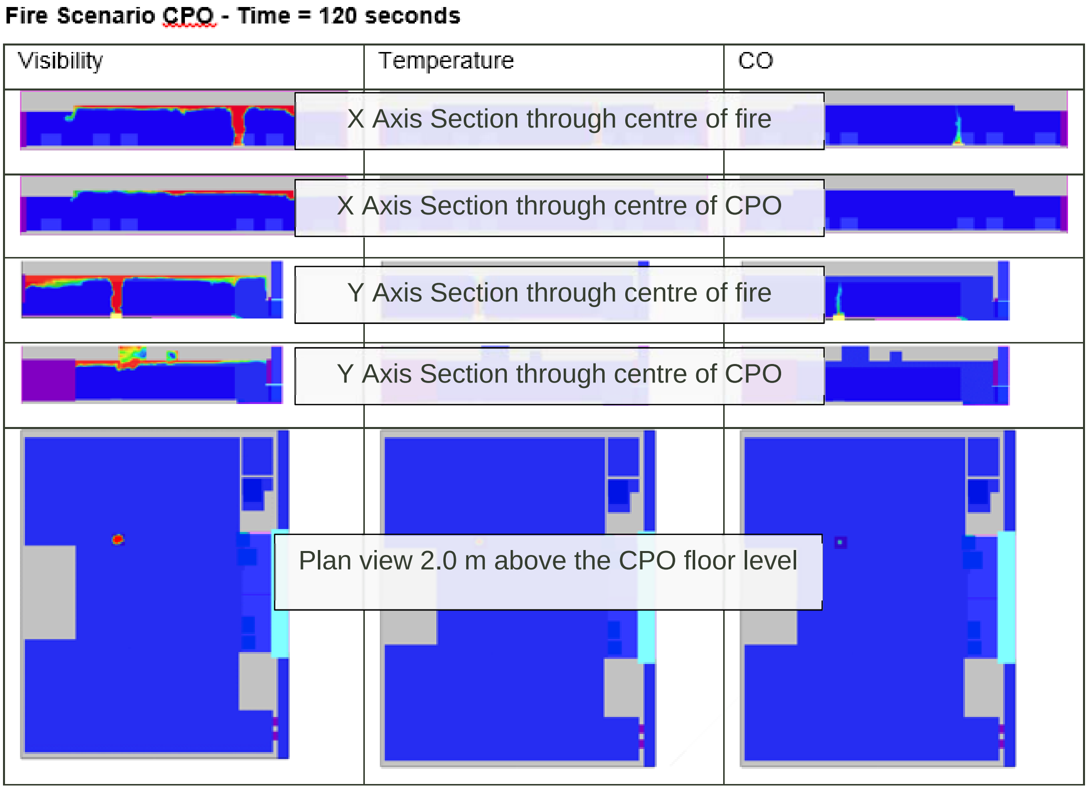
CO Concentration



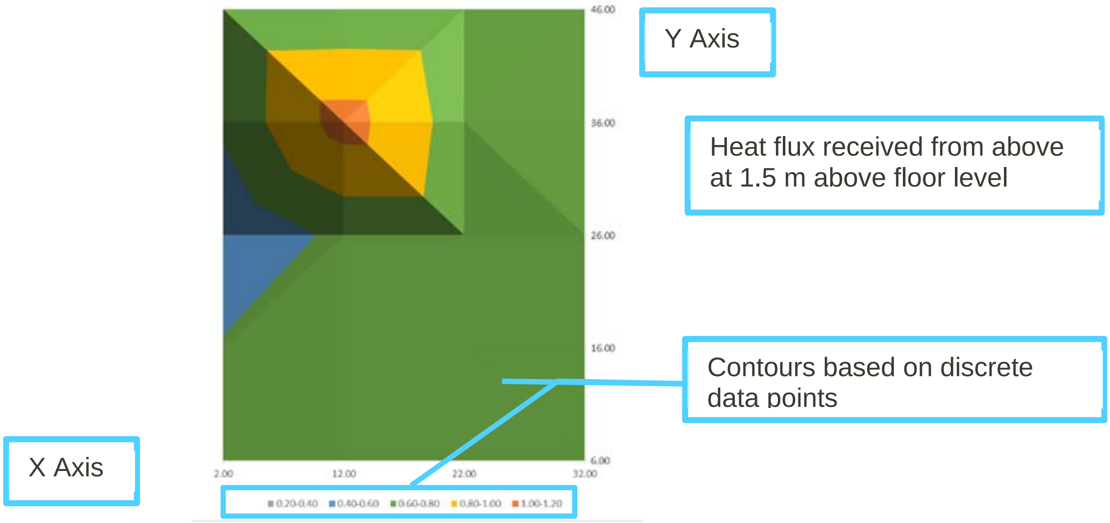
ppm

Views

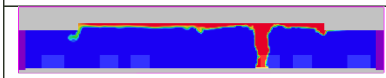
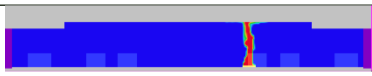
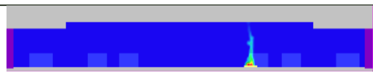
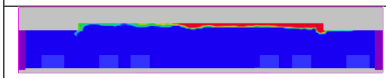
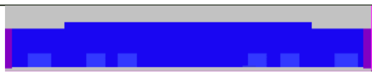
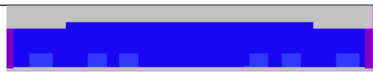
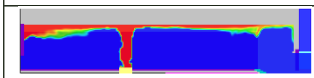
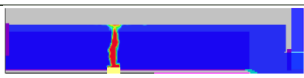
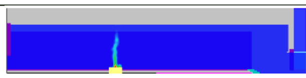
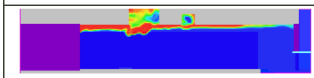
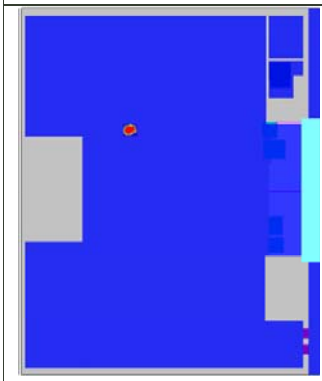
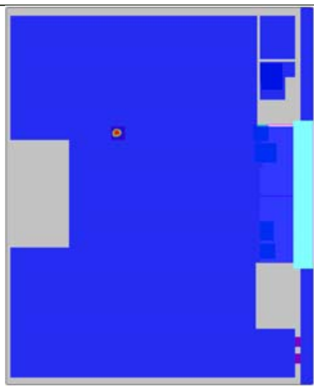
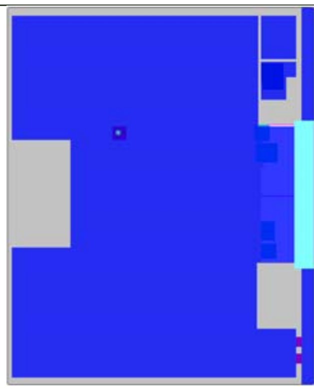
The following views have been used in this report to depict the quantitative results for each simulation listed above.



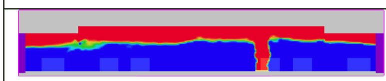
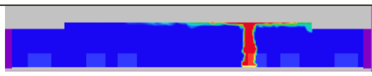
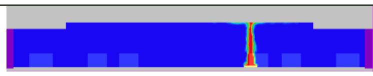
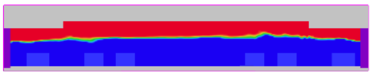
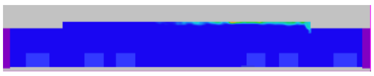
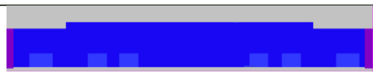
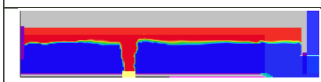
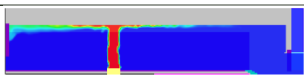
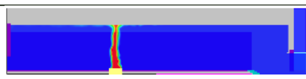
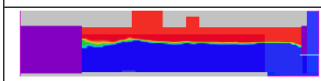
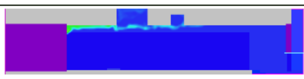
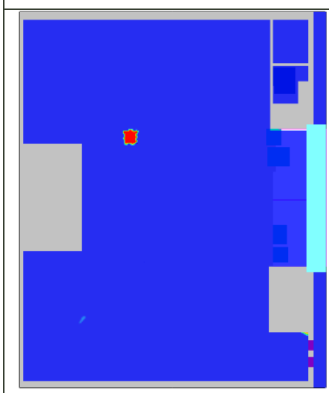
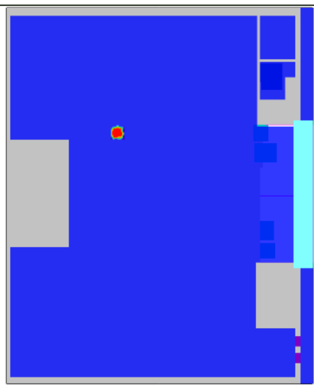
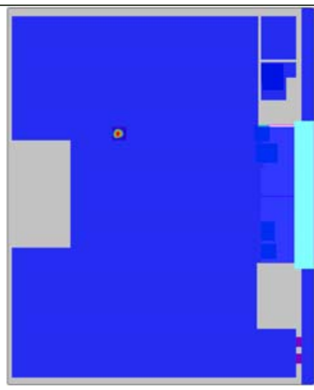
The following graph shows an example of the heat fluxes as measured by devices in the simulations to assess performance relative to the acceptance criteria.



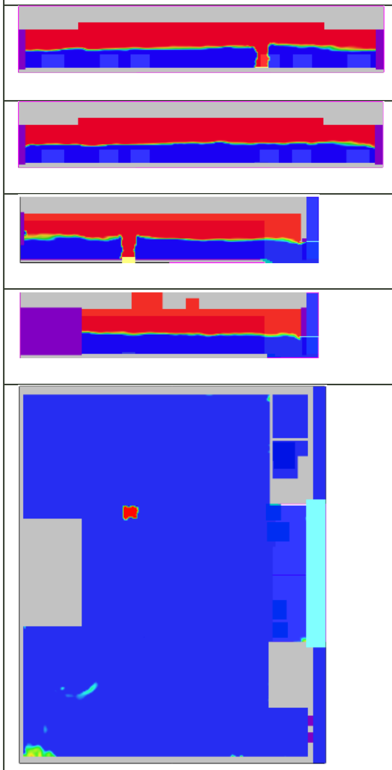
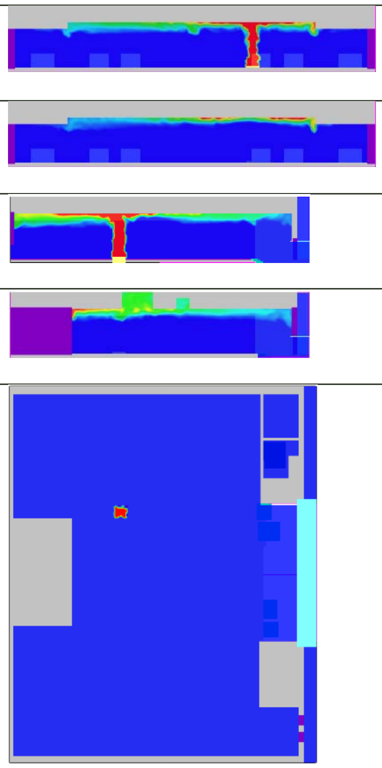
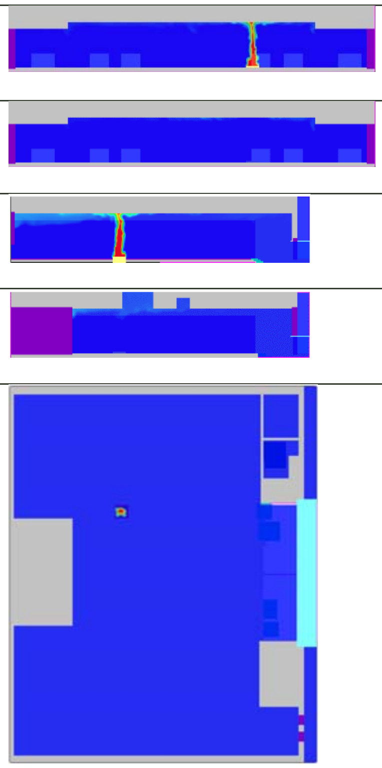
Fire Scenario CPO - Time = 120 seconds

Visibility	Temperature	CO
		
		
		
		
		

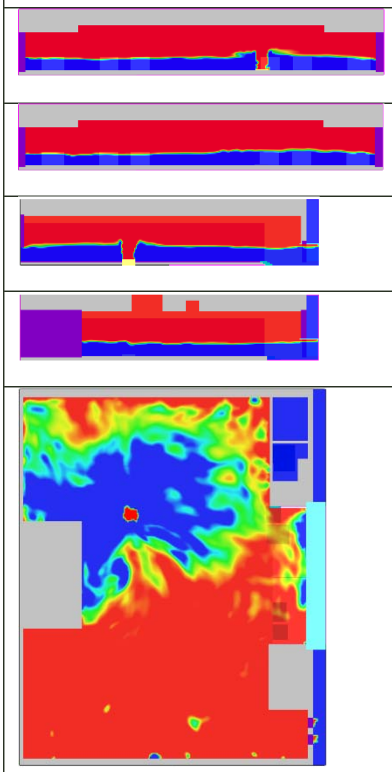
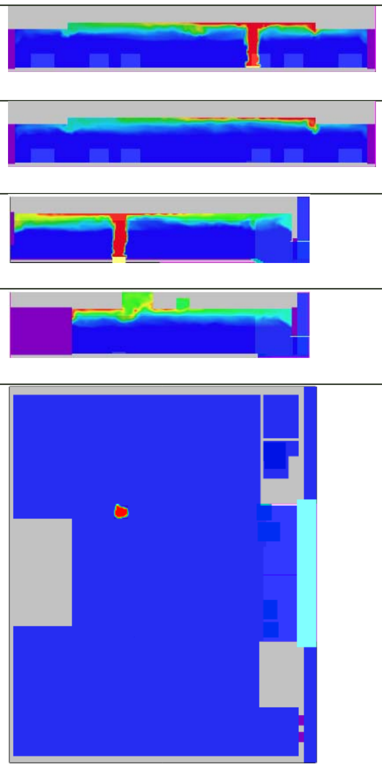
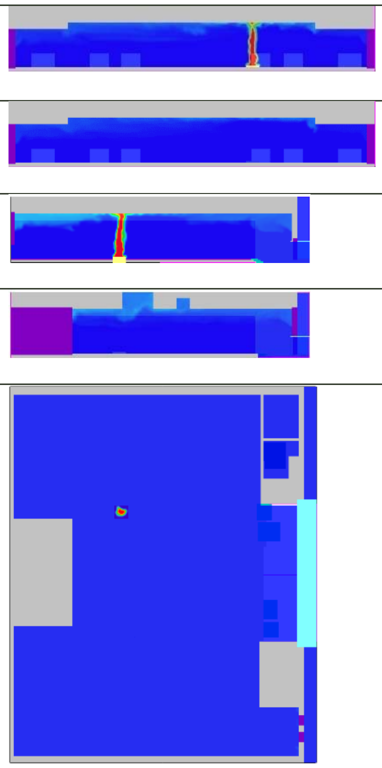
Fire Scenario CPO - Time = 240 seconds

Visibility	Temperature	CO
		
		
		
		
		

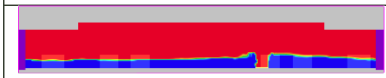
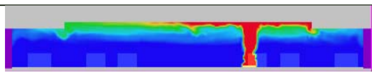
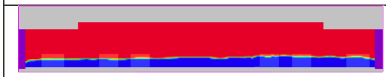
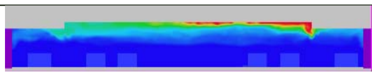
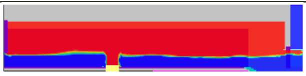
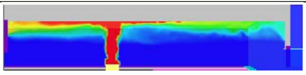
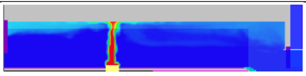
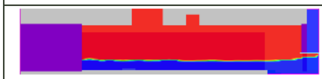
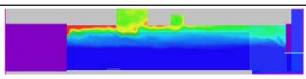
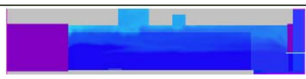
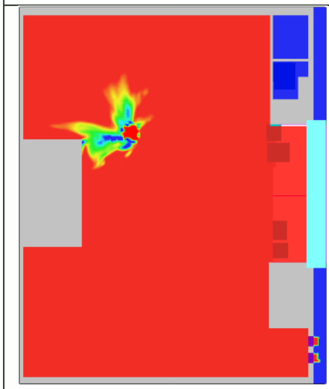
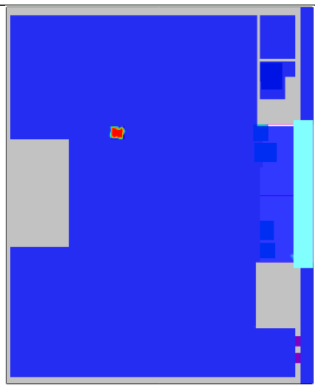
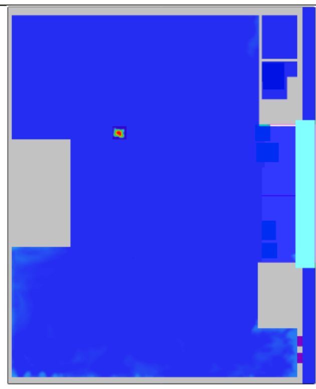
Fire Scenario CPO - Time = 360 seconds

Visibility	Temperature	CO
		

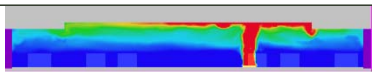
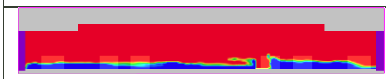
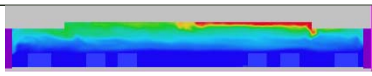
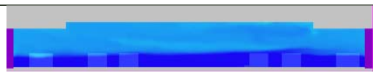
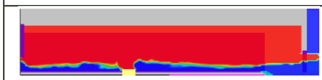
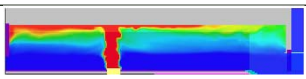
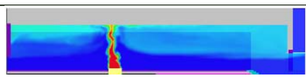
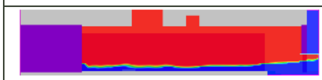
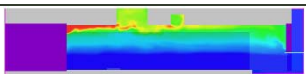
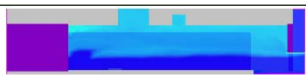
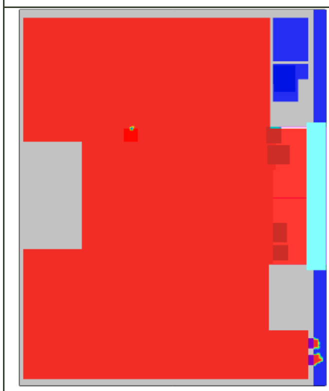
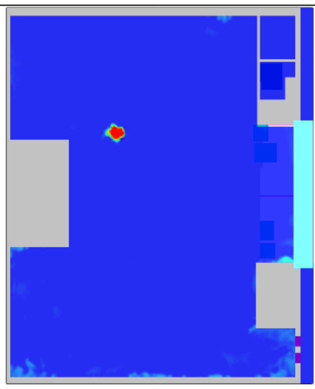
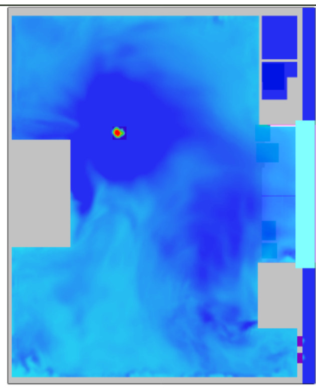
Fire Scenario CPO - Time = 480 seconds

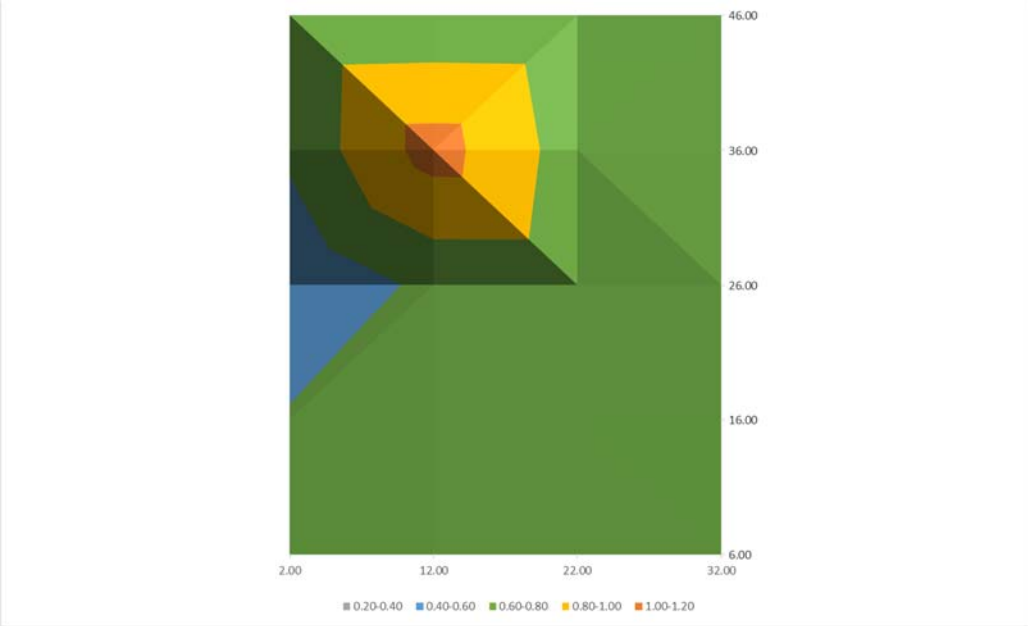
Visibility	Temperature	CO
		

Fire Scenario CPO - Time = 600 seconds

Visibility	Temperature	CO
		
		
		
		
		

Fire Scenario CPO - Time = 1,092 seconds

Visibility	Temperature	CO
		
		
		
		
		


46.00
36.00
26.00
16.00
6.00
2.00
12.00
22.00
32.00
0.20-0.40
0.40-0.60
0.60-0.80
0.80-1.00
1.00-1.20

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Appendix K
Example Egress Calculation

Egress Scenario 1: Base Case

Parameter		NFPA130 2015
Platforms, corridors, and ramps of 4% slope or less:		
Walking speed (platform)	m/min	37.7
Walking speed (concourse)	m/min	61
Flow	p/m.min	81.9
Stairs and ramps of over 4% slope - "up" direction:		
Walking speed (along slope)	m/min	14.6
Flow	p/m.min	55.5
Escalators (from project design data & tread size):		
Britomart Audit	p/min	75
Walking speed (along slope)	m/min	14.6
Stopped flow (walking upwards)	p/m.min	55.5
Doors		
Flow	p/m.min	81.9
Flow single leaf door	p/min	60
Ticket Barriers		
Clear opening of 500 mm	p/min.gate	50
emergency gates designed as single leaf doors	p/min.gate	60

Occupant Load

Total Occupant Load	2600			
East	**Base Case**			
Platform 1/2	933	20%	186.6	20
Platform 3	736	20%	147.2	20
Platform 4/5	933	20%	186.6	20
Total	2602		520.4	

Britomart East exit widths

Basement 2 to Basement 1

			Width (m)			Capacity [p/min]
		Platform 1/2				
	down	Esc 2.1	1.30			72.4
		Stair 5	1.50			83.3
		Sub Total	2.80		C_{E1A}	**155.6**
		Platform 3				
	down	Esc 3.1	1.30			72.4
		Stair 6	1.50			83.3
		Sub Total	2.80		C_{E1B}	**155.6**
		Platform 4/5				
	down	Esc 4.1	1.30			72.4
		Stair 7	1.50			83.3
		Sub Total	2.80		C_{E1C}	**155.6**
		Total	8.41			
Basement 1 to Ground						
Gateline	*Fare barrier*		0.50	no.	8	400.0
	Emergency gate		1.64			134.6
					C_{E2}	**534.6**
	down	Esc 7.1	1.50			83.3
	up	Esc 8.1	1.50			75.0
		Stair 12/13	2.80			155.4
		Total	5.80		C_{E3}	**313.7**

Britomart East Travel Distances

					Travel Time [min]
Platform length			160	m	
T_{E1A}	Platform 1/2 to Stairs/Esc		32	m	0.85
T_{E2VA}	Stairs/ Esc	vertical	16	m	1.10
T_{E3A}	Stairs/ Esc to fare gate		20	m	0.53
T_{E1B}	Platform 1/2 to Stairs/Esc		32	m	0.85
T_{E2VB}	Stairs/ Esc	vertical	16	m	1.10
T_{E3B}	Stairs/ Esc to fare gate		20	m	0.53
T_{E1C}	Platform 1/2 to Stairs/Esc		32	m	0.85
T_{E2C}	Stairs/ Esc	vertical	16	m	1.10
T_{E3C}	Stairs/ Esc to fare gate		20	m	0.53
T_{E4}	Faregate to Stairs/Esc		12	m	0.20
T_{E5V}	Stairs/ Esc	vertical	12	m	0.82
					3.49 minutes

Emergency Exit Capacity

Waiting at Platform Exits

W1 (waiting time at platform exits) = Occupancy Load / Available Exit Capacity

W_{1A}	=	187 / 156	=	1.20	minutes
W_{1B}	=	147 / 156	=	0.95	minutes
W_{1C}	=	187 / 156	=	1.20	minutes

Walking time for longest route

T_{E1A}	T_{E1B}	T_{E1C}	0.85	minutes
T_{E2VA}	T_{E2VB}	T_{E2C}	1.10	minutes
T_{E3A}	T_{E3B}	T_{E3C}	0.53	minutes
T_{E4}			0.20	minutes
T_{E5V}			0.82	minutes
T_W	**Total**		**3.49**	**minutes**

Additional Waiting Time at Platform Exits

Platform 1/2							
W_{0A}	=	W_{1A}	-	T_{E1A}			
	=	1.2	-	0.85	=	0.35	minutes
Platform 3							
W_{0B}	=	W_{1B}	-	T_{E1B}			
	=	0.9	-	0.85	=	0.10	minutes
Platform 4/5							
W_{0C}	=	W_{1C}	-	T_{E1C}			
	=	1.2	-	0.85	=	0.35	minutes

Additional Waiting Time at Fare Barriers

W2	=	Total East Occupant Load / Gate Capacity			
W2	=	520 / 534.6	=	1.0	minutes

Additional Waiting Time at Concourse Stairs

W3	=	Total Occupant Load / Exit Capacity			
W3	=	520 / 313.7	=	1.7	minutes

Total Exit Time

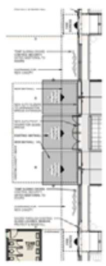
T_t	=	T_w				
	+	(	W1	-	T1	)
	+	(	W2	-	W1	)
	+	(	W3	-	max(W1,W2)	)
T_t	=	3.5				
	+	(	1.2	-	0.8	)
	+	(	1.0	-	1.2	)
	+	(	1.7	-	1.2	)
T_t	=	3.5				
	+	(	0.4)			
	+	(	0.0)			
	+	(	0.5)			
T_t	=	**4.3**	**minutes**			

Occupant Load

Total Occupant Load	**2600**			
West	**Base Case**			
Platform 1/2	933	80%	746.4	80
Platform 3	736	80%	589	80
Platform 4/5	933	80%	746.4	80
Total	2602		2081.6	

Temporary Works exit widths

			Width (m)		fraction total	Capacity [p/min]
Fare Gates						
		Fare barrier	*0.50*	*no.*	*13*	650
		Accessible gate	*1.00*	*no.*	*2*	120
		Emergency gate	*1.72*			141
					C_{W1}	**910.9**
West End Basement 2 to Basement 1						
		New Temp Stair T21	1.70			94.4
		Exisiting Stair 2	2.90			161.0
	up	Esc 1.3	1.00			75.0
	down	Esc 1.2	1.00			55.5
	OUT	Esc 1.1	1.00			
		Existing Stair 1	2.90			161.0
		New Temp Stair T20	1.70			94.4
		Total	**12.20**		C_{W2}	**641.1**
West End Basement 1 to Ground						
		New Temp Stair T21	1.7			
		New Temp Stair T23	3.50			194.3
		New Temp Stair T22	3.50			194.3
		New Temp Stair T20	1.7			
Total			**10.40**		C_{W3}	**388.5**
Ground Floor Exits						
			2.4			196.56
			1.60			131.0
			1.60			131.0
			1.75			143.3
			1.75			143.3
			1.60			131.0
			1.60			131.0
	Total		**9.90**		C_{W4}	**810.8**
			2.4			196.56
					C_{W4A}	393.12



Britomart West Travel Distances

Platform length			160	m	
					Travel Time [min]
$T_{W1A\to W2}$	Platform 1/2 to fare gate		128	m	3.40
$T_{W1B\to W2}$	Platform 3 to fare gate		136	m	3.61
$T_{W1C\to W2}$	Platform 4/5 to fare gate		136	m	3.61
T_{W3}	Fare gate to stairs		14	m	0.37
T_{W4V}	Stairs/ Esc	vertical	15	m	1.03
T_{W5}	Stairs/ Esc to Stairs		11	m	0.29
T_{W4VA}	Stairs/ Esc to Doors	vertical	34	m	2.33
T_{W6V}	Stair	vertical	15	m	1.03
T_{W7}	Stairs to GlassHouse Doors		18	m	0.48

Emergency Exit Capacity

Waiting at Platform Exits

W1 (waiting time at fare gates) = $\frac{\text{Occupancy Load}}{\text{Available Exit Capacity } C_{W1}}$

$$W_1 = \frac{2082}{911} = 2.29 \text{ minutes}$$

Walking time for longest route

T_{W1A-w2}	T_{W1B-w2}	T_{W1C-w2}	3.61	minutes
T_{W3}			0.37	minutes
T_{W4V}			1.03	minutes
T_{W5}			0.29	minutes
T_{W6V}			1.03	minutes
T_{W7}			0.48	minutes
	Total		**6.80**	**minutes**
T_{W1A-w2}	T_{W1B-w2}	T_{W1C-w2}	3.61	minutes
T_{W3}			0.37	minutes
T_{W4VA}			2.33	minutes
	Total		**6.31**	**minutes**

Additional Waiting Time at Platform Exits

Platform 1/2

$$W_{0A} = W_{1A} - T_{E1A}$$

$$= 2.3 - 3.40 = -1.11 \text{ minutes}$$

0.00

Additional Waiting Time at B2 Stairs

$$W_2 = \frac{\text{Total Occupant Load}}{\text{Exit Capacity } C_{W2}}$$

$$W_2 = \frac{2082}{641.1} = 3.2 \text{ minutes}$$

Population Adjustment - B1 Occupant Load

B1 Concourse Occupant Load = Total Occupant Load - W_2 x Stair Capacity

B1 Concourse Occupant Load = 2082 - 3.2 x 188.7 = 1469 people

Additional Waiting Time at B1 Concourse Stairs

$$W_3 = \frac{\text{B1 Occupant Load}}{\text{Exit Capacity } C_{W3}}$$

$$W_3 = \frac{1469}{388.5} = 3.8 \text{ minutes}$$

Additional Waiting Time at Glasshouse Doors

$$W_4 = \frac{\text{B1 Occupant Load}}{\text{Exit Capacity } C_{W4}}$$

$$W_4 = \frac{1469}{810.8} = 1.8 \text{ minutes}$$

$$W_{4A} = \frac{\text{B2 - Grd Stair Occupant Load}}{\text{Exit Capacity } C_{W4}}$$

$$W_{4A} = \frac{613}{393.1} = 1.6 \text{ minutes}$$

Total Exit Time

T_t	=	T_w				
	+	(	W1	-	T1	)
	+	(	W2	-	W1	)
	+	(	W3	-	max(W1,W2)	)
	+	(	W4	-	max(W1,W2,W3)	)
T_t	=	6.8				
	+	(	2.3	-	3.6	)
	+	(	3.2	-	2.3	)
	+	(	3.8	-	3.2	)
	+	(	1.8	-	3.8	)
T_t	=	6.8				
	+	(	0.0	)		
	+	(	1.0	)		
	+	(	0.5	)		
	+	(	0.0	)		
T_t	=	**8.3**	**minutes**			

Occupant Load

Total Occupant Load	2600				
West	Base Case				
Platform 1/2	933	80%	746.4		80
Platform 3	736	80%	589		80
Platform 4/5	933	80%	746.4		80
Total	2602		2081.6		

Permanent Works exit widths

			Width (m)	fraction total	Capacity [p/min]
West End Basement 2 to Basement 1					
		Exisiting Stair 2	2.90		161.0
	up	Esc 1.3	1.00		75.0
	down	Esc 1.2	1.00		55.5
	down	Esc 1.1	1.00		55.5
	out	Esc 1.4	1.00		
		New Stair 1	1.70		94.4
		Lobby & stair doors	2.20		180.2
		Fire Intervention Sta	3.20		177.6
		Total	**10.80**	C_{P1}	**441.3**
West End Basement 1 to Ground					
		Existing Stair 11	2.20	0.268	122.1
	up	Esc 6.2	1.00	0.122	75.0
	down	Esc 6.1	1.00	0.122	55.5
	out	Esc 5.1	1.00	0.122	
	down	Esc 5.2	1.00	0.122	55.5
		New Stair 10	2.00	0.244	111.0
		Total	**8.20**	C_{P2}	**419.1**
CPO Fare Gates					
	Fare barrier		*0.50*	no. 16	800
	Accessible gate		*1.00*	no. 2	120
	Emergency gate		*2.12*		174
				C_{P3}	**1093.6**
Glasshouse Fare Gates					
	Fare barrier		*0.50*	no. 0	0
	Accessible gate		*1.00*	no. 2	120
	Emergency gate/s		*0.00*		0
				C_{P3A}	**120.0**
Ground Floor Exits					
CPO		Station Entry A	2.30		188.4
		Station Entry B	2.30		188.4
		Station Entry C	2.30		188.4
		Station Entry D	2.30		188.4
		Station Entry E	1.50		122.9
		Station Entry F	1.50		122.9
		Station Entry G	1.50		122.9
		Station Entry H	1.50		122.9
		Door to vesibule	2.60		212.9
		Retail 800	3.00		245.7
		Retail 805	3.00		245.7
		Total	**15.20**	C_{P4}	**1244.9**
Glasshouse		Glasshouse (Station Entry I)	3.60		294.8
				C_{P4A}	**294.8**

Britomart West Travel Distances

Platform length 160 m

			Distance	Travel Time [min]
T_{P1A}	Platform 1/2 to stairs		128 m	3.40
T_{P1B}	Platform 3 to stairs		150 m	3.98
T_{P1C}	Platform 4/5 to stairs		150 m	3.98
T_{P2}	Stairs/ Esc	vertical	15 m	1.03
T_{P3}	Stairs/ Esc to Stairs		11 m	0.29
T_{P4}	Stairs/ Esc	vertical	12 m	0.82
T_{P5}	Stairs/ Esc to CPO fare gate		9 m	0.24
T_{P5A}	Stairs/ Esc to Glasshouse fare gate		35 m	0.93
T_{P6}	CPO fare gate to CPO doors		30 m	0.80
T_{P6A}	Glasshouse fare gate to GH doors		1 m	0.03

Emergency Exit Capacity

Waiting at Platform Exits

W1 (waiting time at B2 Stairs) = $\dfrac{\text{Occupancy Load}}{\text{Available Exit Capacity } C_{E1}}$

$$W_1 = \frac{2082}{441} = 4.72 \text{ minutes}$$

Walking time for longest route

T_{F1A}	T_{F1B}	T_{F1C}	3.98	minutes
T_{F2}			1.03	minutes
T_{F3}			0.29	minutes
T_{F4}			0.82	minutes
T_{F5}			0.24	minutes
T_{F6}			0.80	minutes
	Total		**7.15**	**minutes**

T_{F1}	T_{F1B}	T_{F1C}	3.98	minutes
T_{F2}			1.03	minutes
T_{F3}			0.29	minutes
T_{F4}			0.82	minutes
T_{F5A}			0.93	minutes
T_{F6A}			0.03	minutes
	Total		**7.07**	**minutes**

Additional Waiting Time at Platform Exits

Platform

$$W_p = W_1 - T_{F1}$$

$$= 4.7 - 3.98 = 0.74 \text{ minutes}$$

0.74

Additional Waiting Time at B1 Stairs

$$W_2 = \frac{\text{Total Occupant Load}}{\text{Exit Capacity } C_{E2}}$$

$$W_2 = \frac{2082}{419.1} = 5.0 \text{ minutes}$$

Population Adjustment - CPO Exit/ Glass House Exit

CPO Exit Occupant Load = Total Occupant Load x CPO Faregate capacity / Total Faregate Capacity

CPO Exit Occupant Load = 2082 x 1093.6 / 1213.6 = 1876 people

Additional Waiting Time at CPO Faregates

$$W_3 = \frac{\text{CPO Exit Occupant Load}}{\text{Exit Capacity } C_{E3}}$$

$$W_3 = \frac{1876}{1093.6} = 1.7 \text{ minutes}$$

Additional Waiting Time at CPO Doors

$$W_4 = \frac{\text{CPO Exit Occupant Load}}{\text{Exit Capacity } C_{E4}}$$

$$W_4 = \frac{1876}{1244.9} = 1.5 \text{ minutes}$$

Additional Waiting Time at Glasshouse Faregates

$$W_{3A} = \frac{\text{GH Exit Occupant Load}}{\text{Exit Capacity } C_{E3A}}$$

$$W_{3A} = \frac{206}{120.0} = 1.7 \text{ minutes}$$

Additional Waiting Time at Glasshouse Doors

$$W_{4A} = \frac{\text{GH Exit Occupant Load}}{\text{Exit Capacity } C_{E4A}}$$

$$W_{4A} = \frac{206}{294.8} = 0.7 \text{ minutes}$$

Total Exit Time via CPO

$$T_t = T_w + (W1 - T1) + (W2 - W1) + (W3 - \max(W1,W2)) + (W4 - \max(W1,W2,W3))$$

$$T_t = 7.2 + (4.7 - 4.0) + (5.0 - 4.7) + (1.7 - 5.0) + (1.5 - 5.0)$$

$$T_t = 7.2 + (0.7) + (0.2) + (0.0) + (0.0)$$

$$T_t = \mathbf{8.1 \text{ minutes}}$$

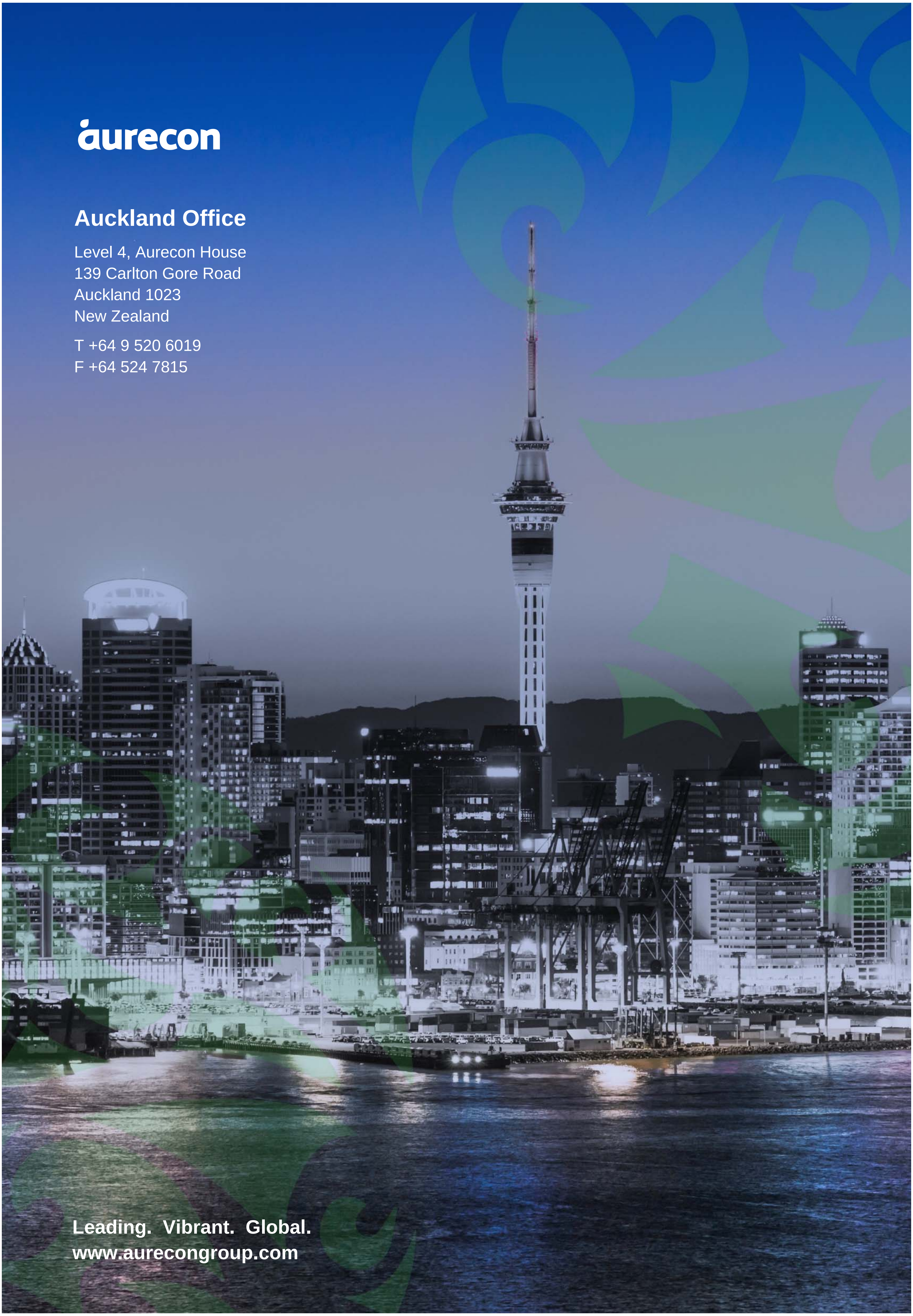
Total Exit Time via Glasshouse

$$T_t = T_w + (W1 - T1) + (W2 - W1) + (W3A - \max(W1,W2)) + (W4A - \max(W1,W2,W3A))$$

$$T_t = 7.1 + (4.7 - 4.0) + (5.0 - 4.7) + (1.7 - 5.0) + (0.7 - 5.0)$$

$$T_t = 7.1 + (0.7) + (0.2) + (0.0) + (0.0)$$

$$T_t = \mathbf{8.1 \text{ minutes}}$$



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