Reliable Knowledge & Services

Consultant Advice Note

**From:** Xijuan Liu **Date:** 16 July 2019 **Ref:** 2019-001-CAN002

**Project: Qantas Group Flight Training Centre**

| | | | | |
|---|---|---|---|---|
| **To:** | Charlie Westgarth | Qantas | Nicholas Lawler | Qantas |
| | Michael Terrett | APP | Emma Fitzgerald | Urbis |
| | Darren Giffen | NGA | Stephanie Morgia | NGA |
| | Stan Kafes | CBRK | Tim Rogers | CBRK |
| | Jason Krzus | SWP | | |

# Response to FRNSW Comments on SSD

## Objective

FRNSW provided Recommendations to the NSW Department of Planning & Environment for consideration in relation to the Environmental Impact Statement (EIS) of the Qantas Flight Training Centre development, including the Flight training Centre building and the multilevel carpark building, in FRNSW letter dated 27th June 2019, File Ref. No: FRN16/1725 BFS19/1827 (8000007686). We propose the following response to FRNSW comments.

## Suggested response

The design team has been proactive in seeking FRNSW input; a consultation meeting was held with FRNSW on 3rd April 2019 regarding fire hydrant booster assemblies and vehicular access; several other deviations from NCC *deemed-to-satisfy* (DtS) provisions were also discussed. FRNSW comments were incorporated in the design. A FEBQ (fire engineering brief questionnaire) is being prepared for submission to FRNSW to facilitate in detail consultation.

***i) Location of fire hydrant booster assemblies***

FRNSW advice at the consultation meeting was followed in locating the fire hydrant booster assemblies.

- The fire hydrant booster assembly will be located along and parallel to King Street as preferred by FRNSW.
- The fire hydrant booster assembly of the carpark will be located at the southwest corner, in the south elevation adjacent to the carpark entry.

***ii) Use of manual call points for activation of an emergency warning***

The main activation mechanism of activating emergency warning and fire brigade notification is automatic fire detection system, including in the open deck carpark where heat detectors with extended spacing are proposed beyond DtS requirements to enable automatic activation. Where manual call points are used, they will be supplementing rather than replacement of the automatic activation.

### *iii) FRNSW policy No. 4 – Guidelines for Emergency Vehicle Access*

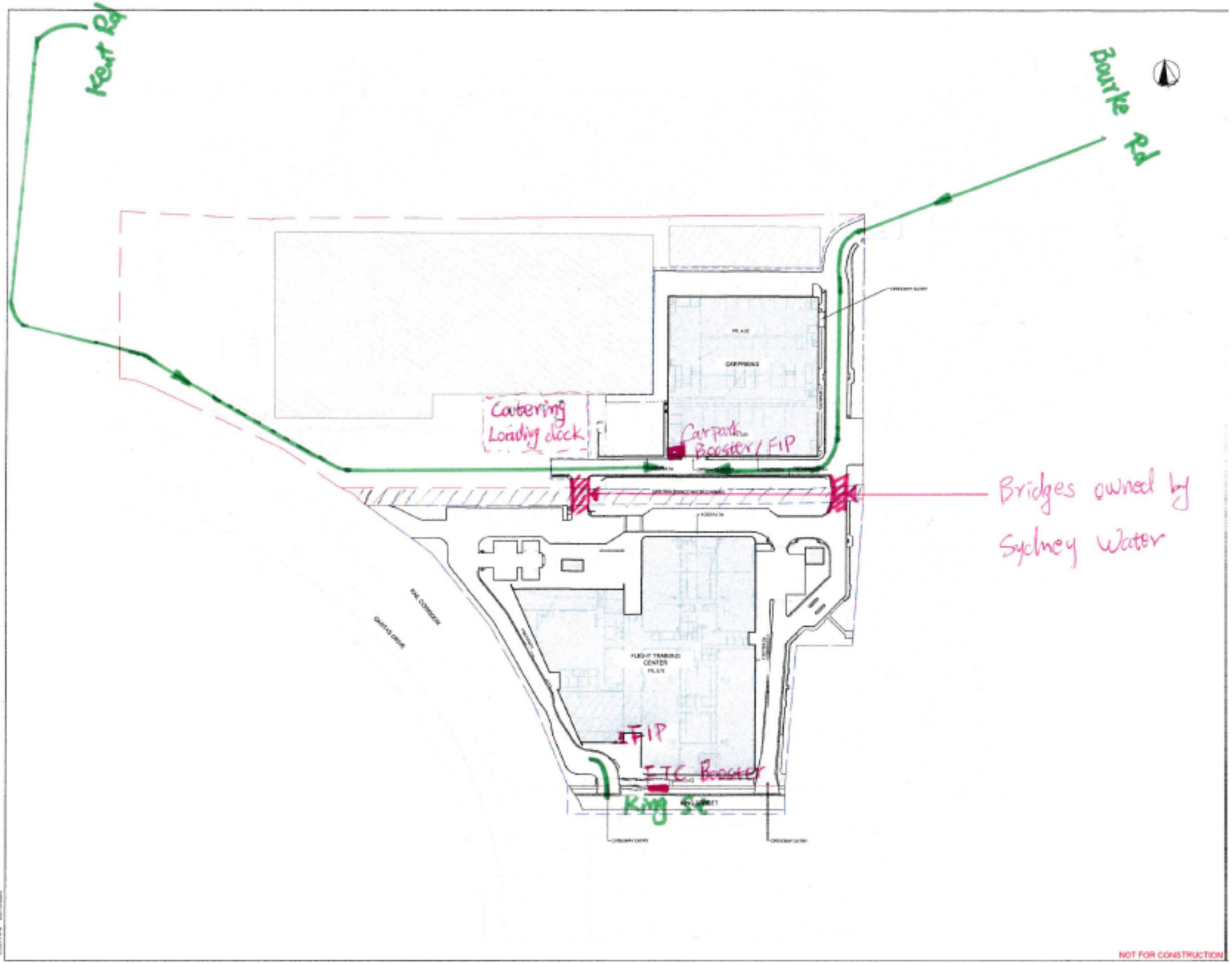
The Guidelines will be complied with in the design of onsite carriageways.

The Flight Training Centre building is to be accessed from King Street, as per discussion with FRNSW at the consultation meeting.

Emergency vehicular access to the Carpark will be available via internal driveways on the Qantas campus accessed from Bourke Road on the east and Kent Road on the west. If required, the nearby loading dock of the Qantas Catering building may also provide a hardstand.

It is noted that the existing Sydney Water channel is between, and is outside of, the sites of the Flight Training Centre and the Carpark. Two existing bridges over the channel which are owned by Sydney Water connect the two sites. Qantas is not responsible for maintaining the bridges and cannot guarantee the load capacity will always be sufficient for emergency vehicular access. For this reason emergency access to the carpark is not proposed to be from King Street, to avoid the need to go over these bridges.

As per FRNSW request at the consultation meeting, an overall site plan including the Flight Training Centre and the Carpark will be provide at the booster assembly of both buildings. The plan will show the access road to each building, the locations of fire hydrant booster assemblies and the fire indicator panels. The bridges over the Sydney Water Channel will also be marked out for precaution. An example of the plan is shown in the next page (NGA to improve for submission).


Kent Rd
Bourke Rd
Catering
Loading dock
Carpark
Booster/FIP
Bridges owned by
Sydney Water
FIP
FTC Booster
King St
NOT FOR CONSTRUCTION

# Qantas Group Flight Training Centre
# 297 King Street Mascot

## Fire Engineering Brief

Ref: 2019 – 001ND – FEB - 1
May 28, 2019
Rev 2

**FOR QANTAS AIRWAYS LIMITED**

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# Qantas Group Flight Training Centre
# 297 King Street Mascot

## Fire Engineering Brief

Ref: 2019 – 001ND – FEB - 1
May 28, 2019
Rev 2

Prepared for: Qantas Airways Limited
Prepared by: XEL Consulting Pty Ltd
ABN: 30141218966



**Document Control**

| Revision | Date | Purpose | Author | |
|---|---|---|---|---|
| 1 | May 16, 2019 | For project team review | Xijuan Liu | |
| 2 | May 28, 2019 | For submission to FRNSW | Xijuan Liu | X. Liu |
| | | | | |
| | | | | |

# Executive Summary

This fire engineering brief report relates to the development of a new flight training centre at 297 King Street, Mascot NSW 2020. The project will also consist of a standing alone multi-deck carpark building which is subject to a separate fire engineering study and associated reports.

The site forms part of a larger land holding under the ownership of Qantas that generally extends between Qantas Drive to the west, Ewan Street to the south, Coward Street to the north, with the Qantas “Corporate Campus” fronting Bourke Road. Vehicular access to the site from the local road network is available from King Street.

The QGFTC building comprises two major parts. The Flight Training Centre (FTC) will contain four levels, with twelve to fourteen (12 - 14) flight simulation bays that will house aircraft simulators (SIMs) distributed in four SIM halls connecting the lower three levels. The top level is separated from the lower levels and will be used as offices. The Emergency Procedure (EP) hall will contain training, class rooms and exam rooms over 2 levels on three sides of a double rise hall. The two parts are joined via the entry and EP Raft Hall in the middle.

In the context of the BCA (Building Code of Australia) the building is Class 9b, has a rise in storey of 4 and an effective height of 12.55m. It will have mixed types of construction. The four level FTC will be of Type A Construction. The two level EP hall will be a separate fire compartment and Type B Construction. A BCA report by Steve Watson & Partners identified deviations from the following *deemed-to-satisfy* provisions which may be subject to a Performance Solution to satisfy relevant Performance Requirements of the BCA.

- C2.7 Separation by fire walls – fire walls between fire compartments not through all levels; separation involves fire rated slabs of FRL not less than that of the fire walls.
- C3.3 Separation of external walls and associated openings in different fire compartments – opening protection from one of two adjacent fire compartments only to prevent fire spread both ways;
- D1.3 required stair in the EP hall connecting 3 levels and is not fire isolated;
- D1.4 Travel distances – exceeding 20m to single exit and point of choice and exceeding 40m to the nearest exit;
- D1.5 Travel distances between alternative exits via point of choice exceeding 60m;
- D1.12 Non - required stairway connecting 4 storeys and not to be constructed in accordance with Specification D1.12;
- E2.2 and Table E2.2 which requires automatic smoke exhaust system in fire compartments with floor area exceeding 2000m$^2$ in Class 9b buildings; smoke detection variation in the EP hall and over swimming pool;
- Part G3 Atrium Construction and services in atrium.
- D1.6 Reduced width of paths of travel when the full motion envelops of the SIMs are considered obstructs.
- E1.4 Fire hose reels are proposed to be replaced with fire extinguishers throughout the building.

XEL Consulting has been commissioned by Qantas to develop and assess a Building Solution incorporating Performance Solution to satisfy relevant BCA Performance Requirements.
XEL Consulting undertakes the assignment largely in accordance with the process and methods recommended in the International Fire Engineering Guidelines (IFEG). The fire engineering brief (FEB) is the 1st Stage of the fire engineering process. It establishes the frame work of the assessment and identifies the Trial Design to be assessed. This FEB report is utilized to facilitate stakeholder consultation so that stakeholder comments can be incorporated in the assessment and preparation of the fire engineering report (FER). The FER is to be approved by the building certifier for the Performance Solution to be accepted. The main contents of this FEB report as amended to incorporate stakeholders' comments will be included in the FER.

The Trial Design incorporating Performance Solution is detailed in Section 6.

# 1 Introduction

## 1.1 Project Brief

This report relates to the development of a new flight training centre at 297 King Street, Mascot NSW 2020. The project will also consist of a standing alone multi-deck carpark building which is subject to a separate fire engineering study and associated reports.

The site forms part of a larger land holding under the ownership of Qantas that generally extends between Qantas Drive to the west, Ewan Street to the south, Coward Street to the north, with the Qantas "Corporate Campus" fronting Bourke Road. Vehicular access to the site from the local road network is available from King Street.

The QGFTC building comprises two major parts. The Flight Training Centre (FTC) will contain four levels, with twelve to fourteen (12 - 14) flight simulation bays that will house aircraft simulators (SIMs) distributed in four SIM halls connecting the lower three levels. The top level is separated from the lower levels and will be used as offices. The Emergency Procedure (EP) hall will contain training, class rooms and exam rooms over 2 levels on three sides of a double rise hall. The two parts are joined via the entry and EP Raft Hall in the middle.

A BCA report by Steve Watson & Partners identified deviations from the following *deemed-to-satisfy* provisions which may be subject to a Performance Solution to satisfy relevant Performance Requirements of the BCA. The Performance Solution is to be developed and assessed in accordance with the process in the International Fire Engineering Guidelines (IFEG) and involves the following sub-system:

- *Sub-system B* Smoke Development and Spread and Control
- *Sub-system C* Fire Spread and Impact and Control
- *Sub-system D* Fire Detection, Warning and Suppression
- *Sub-system E* Occupant Evacuation and Control
- *Sub-system F* Fire Services Intervention

## 1.2 Relevant stakeholders

The relevant project stakeholders involved in the fire engineering process are outlined in **Table 1-1**.

**Table 1-1 Relevant project stakeholders.**

| Name | Organization | Role |
|---|---|---|
| Charlie Westgarth | Qantas | Owner representative |
| Michael Terrett | APP | Project manager |
| Darren Giffen<br>Stephanie Morgia | Noxon Giffen Architecture | Architect |
| Ashwin Muralidharan | NDY | Fire services engineer |
| Darren Bofinger | Fire & Rescue NSW | Concurrence authority |

| Name | Organization | Role |
|---|---|---|
| Murray Macken<br>Matt Rowley | | |
| Jason Krzus | Steven Watson & Partners | Building certifier |
| Xijuan Liu | XEL Consulting Pty Ltd | Fire safety engineer |

# 2 Scope

## 2.1 Project Context

### *2.1.1 Reference Codes & Guidelines*

This assessment is prepared with reference to the following codes and guidelines:

a) Australian Building Codes Board, *National Construction code Series 2016, Volume One, Building Code of Australia Class 2 to Class 9 Buildings*, 2019 (BCA).

b) Australian Building Codes Board, *National Construction code Series 2016, Guide to Volume One, Building Code of Australia Class 2 to Class 9 Buildings,* 2019 (Guide to the BCA).

c) International Fire Engineering Guidelines, Australian Building Code Board, 2005.

### *2.1.2 Information Considered*

This report is prepared with consideration to the following information:

a)

b) Architectural drawings prepared by Noxon Giffen Architecture as listed in Table 2-1;

c) BCA Assessment Report by Steve Waston & Partners, Report 2019/0208 R1.2, April 2019.

Table 2-1 Referenced drawings

| Drawing No. | Title | Issue | Date |
|---|---|---|---|
| A3.01.01 | QGFT-Site-Plan | T1 | 2019.05.28 |
| A3.03.01 | QGFT- Plan-Overall-L00 | T1 | 2019.05.28 |
| A3.03.11 | QGFT- Plan-Overall-L01 | T1 | 2019.05.28 |
| A3.03.21 | QGFT- Plan-Overall-L02 | T1 | 2019.05.28 |
| A3.03.31 | QGFT- Plan-Overall-L03 | T1 | 2019.05.28 |
| DA3.04 | Plan – Level 3 | DA | 2019.04.11 |
| A3.03.41 | QGFT- Plan-Overall-L04 Roof | T1 | 2019.05.28 |
| A3.04.01 | QGFT-Elevations – Overall | T1 | 2019.05.28 |
| A3.04.02 | QGFT-Elevations – Overall | T1 | 2019.05.28 |
| A3.04.11 | QGFT-Sections – Overall | T1 | 2019.05.28 |
| A3.04.12 | QGFT-Sections – Overall | T1 | 2019.05.28 |

## 2.2 Scope of the Fire Engineering Process

This fire engineering study is composed of developing a Building Solution incorporating Performance Solution and assessing it against relevant Performance Requirements of the BCA. The process of ire engineering consists of two stages, identified by the key deliverables as the Fire Engineering Brief (FEB) stage and the Fire Engineering Report (FER) Stage.

### 2.2.1 FEB Scope

The FEB establishes the frame work of the assessment and develops trial design (s) to be assessed in the FER stage. Following the IFEG[1] , the tasks of the FEB stage include

- Identify scope and objectives for the fire safety engineering assessment;
- Define fire safety acceptance criteria;
- Identify and agree on fire hazards;
- Establish and agree on fire and occupant evacuation scenarios;
- Establish system interaction and levels of redundancy;
- Establish method of assessment;
- Establish the trial design;
- Obtain agreement of the project Stakeholders on the FEB.

This FEB report is utilized to facilitate stakeholder consultation so that stakeholder comments can be considered in the assessment and the preparation of the FER.

### 2.2.2 FER Scope

The trial design will be analysed using input parameters and methods outlined in this report. The analysis results will be collated and evaluated against the Acceptance Criteria selected herein. The trial design may be adjusted as necessary to meet the Acceptance Criteria and thereby to satisfy the relevant Performance Requirements. The assessment will be documented in the FER, which is required to be submitted to the building certifier for the Performance Solution to be approved and implemented in construction. The main contents of this FEB report as amended as necessary to incorporate stakeholders' comments will be included in the FER.

# 3 Design Objectives

## 3.1 Fire Safety Objectives

The design objectives for fire safety are contained in the relevant BCA Performance Requirements in Sections C, D and E which may be summarized as follows:

- Occupant Life Safety – to safeguard people from illness or injury due to a fire in a building and whilst evacuating a building during a fire.
- Fire Brigade Intervention – to facilitate the activities of emergency services personnel.

## 3.2 Limitations of the Study and Reports

Following are limitations of the fire engineering assessment and reports.

- The reports do not apply to those situations where a person is involved, either accidentally or intentionally, with the fire ignition or early stages of development of a fire; building fire safety systems are not generally designed to protect such persons;
- The reports do not encompass situations that involve fire hazards outside the range normally encountered in buildings, such as storage of flammable liquids, processing of industrial chemicals or handling of explosive materials.
- Conventional building design can only provide limited protection against malicious attack. Large scale arson, large quantities of deliberately introduced accelerants, terrorism and multiple ignition sources has not been considered. These events can potentially overwhelm some fire safety systems.
- The goal of 'absolute' or '100%' safety is not attainable and there will always be a finite risk of injury, death or property damage. Fire and its consequent effects on people and property are both complex and variable. Thus, a fire safety system may not effectively cope with all possible scenarios. The intent of regulations related to health, safety and amenity in buildings and this report is to mitigate risks to a level acceptable to the community.
- The fire engineering reports do not address protection of property (other than adjoining property), business interruption or losses, personal or moral obligations of the owner/occupier, reputation, environmental impacts, broader community issues etc., unless specifically required by the client. For this building none of the above matters were not identified by the relevant stakeholders and are therefore not considered in this assessment.
- The study assesses the building as it will be when the proposed Performance Solution has been implemented; it does not address fire safety matters during construction/implementation of the Performance Solution.
- This report contains technical advice that may be used for obtaining building approval as necessary; it cannot replace any building approval/permit/certificate that may be required under relevant building regulation.

# 4 Principal building characteristics

## 4.1 Site Description

The site is located at 297 King Street, Mascot and comprises land known as Lots 2 & 4 DP 234489, Lot 1 DP 202747, Lot B DP 164829 and Lot 133 DP 659434. The site is identified in Figure 4-1.

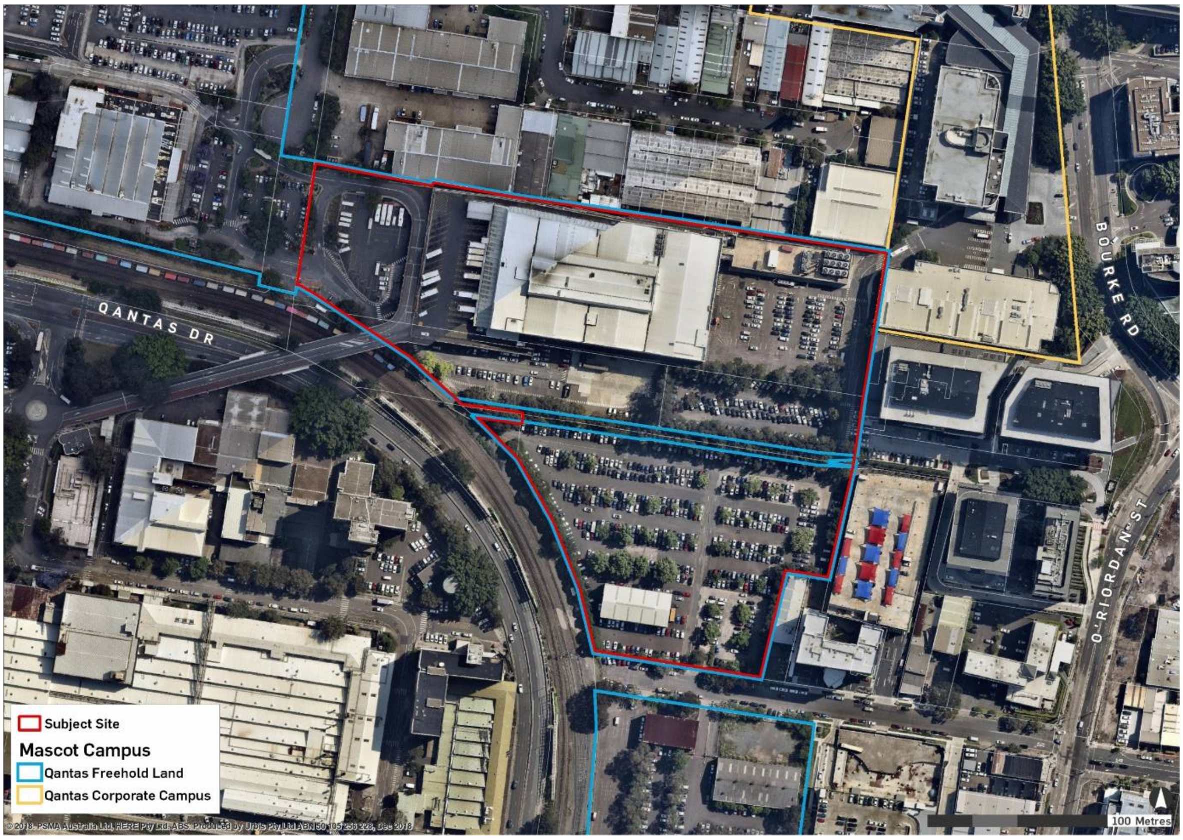



Figure 4-1- The Site

Key features of the site are as follows:

- The site is approximately 5.417ha and is an irregular shape. It is approximately 240m in length and maintains a variable width of between approximately 321m in the northern portion of the site and approximately 93m along the King Street frontage (refer to Figure 1).
- The site possesses a relatively level slope across the site. An open Sydney Water drainage channel bisects the northern portion of the site in an east-west direction. There are some isolated changes in level immediately adjacent to this channel. A Site Survey Plan accompanies the application which details the topographic characteristics of the site.
- Multiple mature Plane Trees are scattered throughout the site. A variety of native and exotic tress and vegetation also exist around the perimeter of the site which help screen the site from surrounding uses.
- Site improvements include at-grade car parking for Qantas staff, an industrial shed to store spare aviation parts, a substation, a disused gatehouse, a Sydney Water Asset with two driveways over it, the Qantas catering facility and Qantas tri-generation plant.

- The site forms part of a larger land holding under the ownership of Qantas that generally extends between Qantas Drive to the west, Ewan Street to the south, Coward Street to the north, with the Qantas "Corporate Campus" fronting Bourke Road.
- Vehicular access to the site from the local road network is available from King Street. The site has intra-campus connections along the northern boundary in the form of two connecting driveways in the north-eastern and north-western corner of the site along the northern boundary which link it to the broader Mascot Campus.
- The site is located within the Bayside LGA.

Key features of the locality are:

- **North:** The site is bounded to the north low scale industrial development, beyond which is Coward Street. Further north of the site is the Mascot Town Centre which is characterised by transport-oriented development including high density mixed-use development focussed around the Mascot Train Station.
- **East:** The site is bordered to the east by commercial development including a newly completed Travelodge hotel which includes a commercial car park. Additional commercial development to the east includes the Ibis Hotel and Pullman Sydney Airport fronting O'Riordan Street.
- **South:** The site is bounded to the south by King Street, beyond which is Qantas owned at-grade car parking and other industrial uses. Further south is the Botany Freight Rail Line and Qantas Drive beyond which is the Domestic Terminal at Sydney Airport.
- **West:** The site is bordered to the west by the Botany Freight Rail Line and Qantas Drive, beyond which lies Sydney Kingsford Smith Airport and the Qantas Jetbase (location of the current Flight Training Centre).

## 4.2 Building usage

The proposed flight training centre will occupy the southern portion of the site. It is a building that comprises 4 core elements as follows:

- An emergency procedures hall that contains;
  - cabin evacuation emergency trainers,
  - an evacuation training pool,
  - door trainers,
  - fire trainers
  - slide descent towers,
  - security room,
  - aviation medicine training and equipment rooms.
- A flight training centre that contains:
  - flight training halls with 14 bays that will house aircraft simulators,
  - integrated procedures training rooms, computer rooms, a maintenance workshop, storerooms, multiple de-briefing and briefing rooms, pilot's lounge and a shared lounge.
- Teaching Space that contains
  - training rooms,

   - classrooms and two computer-based exam rooms.
- Office Space
   - Office space for staff and associated shared amenities including multiple small, medium and large meeting rooms, think tank rooms, informal meeting spaces, a video room and lunch/tea room.

Ancillary spaces including the reception area at the ground floor, toilets, roof plant and vertical circulation. The external ground floor layout will include a loading dock, at-grade car parking for approximately 39 spaces and a bus drop-off zone at the northern site boundary.

## 4.3 BCA parameters

The Flight Training Centre will contain four levels, with the aircraft simulator (SIM) bays connecting the lower three levels. The top level is separated from the lower levels and will be used as offices. The Emergency Procedure (EP) hall will contain 2 levels. The two parts are joined via the entry and EP Raft Hall in the middle. Figure 4-2 shows the Ground Floor plan of the building. Key building characteristics in the context of the BCA that are based on to determine BCA *deemed-to-satisfy* provisions are summarized in Table 4-1 in accordance with the BCA report.

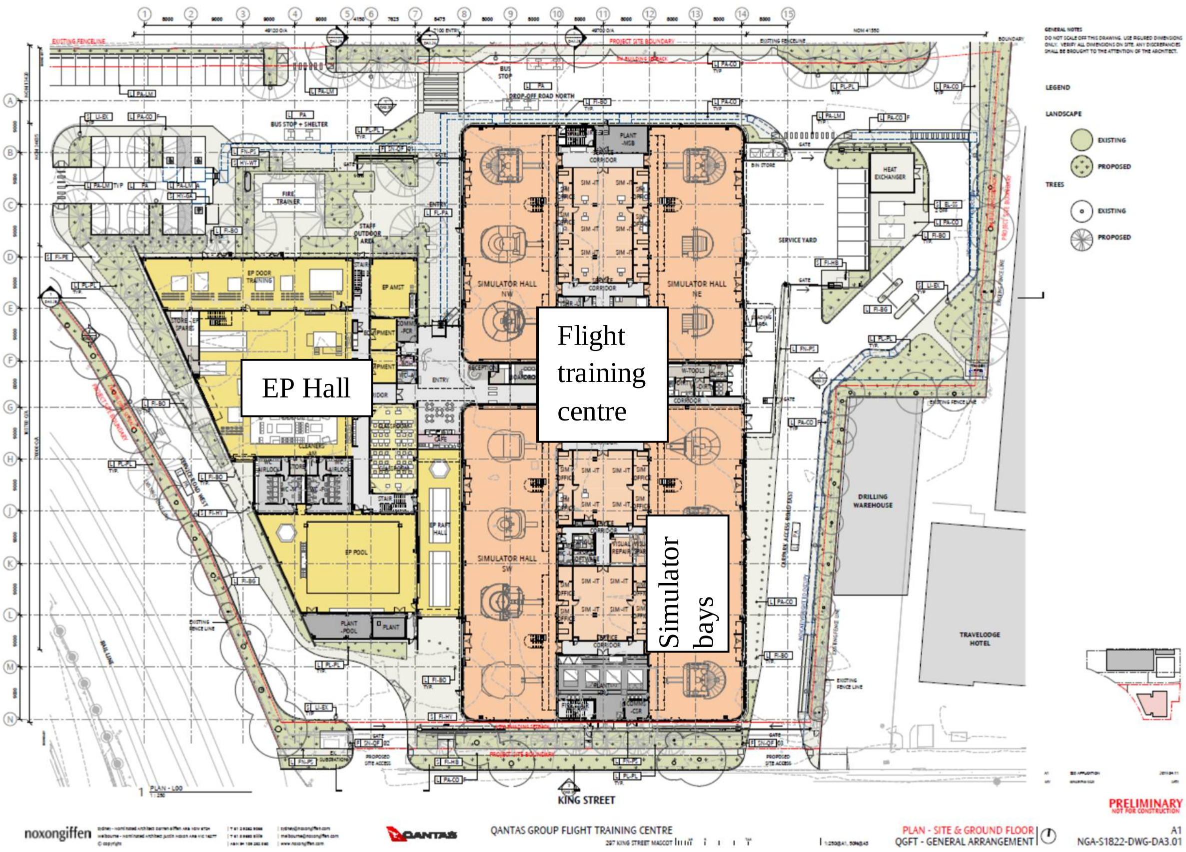


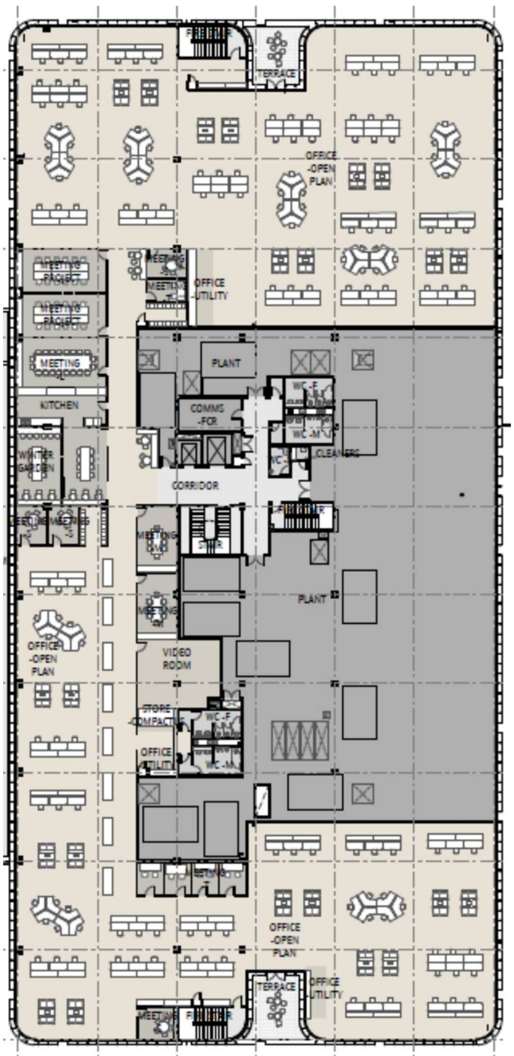

Figure 4-2– Site & Ground Floor Plan of the QGFTC building

Table 4-1 Key determinants for BCA *deemed-to-satisfy* provisions

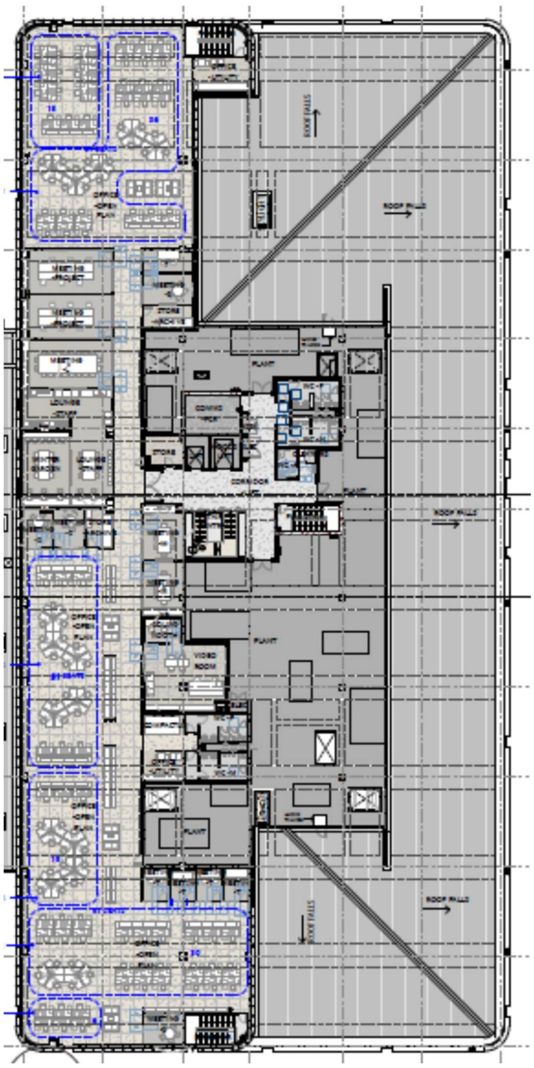
| | |
|---|---|
| Classification | Class 5 - offices<br>Class 9b - education |
| Rise in storey | 4 |
| Type of Construction | Type A – flight training centre<br>Type B – emergency procedures (EP) hall |
| Effective height | 12.55 m |

## 4.4 Design Options for Level 3 Offices

Two design options are being considered for Level 3 offices on top of the SIM halls. The SSD submission included a full floor option, known as the extension option; the tender package shows a roughly half floor (east to west) option. These two layouts are compared in Figure 4-3. The extension option has several more extended travel distance deviations, as discussed in Section 6.3.




(a) Extension option in SSD



(b) reduced floor option in tender

Figure 4-3 Level 3 options

# 5 Dominant occupant characteristics

## 5.1 Population

BCA Clause D1.13 stipulates method of estimating number of occupants for the purpose of DtS provisions, by

a) Dividing the floor area with the area per person listed in Table D1.13;
b) Referencing to the seating capacity in an assembly building or room; or
c) Any other suitable means of assessing its capacity.

As the building is purposely built numbers based on operation requirements provided by Qantas will be adopted for egress assessment. It is noted that the maximum number of occupants in specific areas is assumed for the purpose of egress assessment; movement of the same group of occupants to different areas of the building is not considered. The total population in the building or a part of the building will exceed the estimated population for, e.g. design of amenity facility. The numbers of occupants in classrooms and offices based on provided Schedule – Population attached in Appendix B, are shown in Table 5-1.

Table 5-1 – Number of occupants in various areas

| Level | EP | SIM |
|---|---|---|
| L00 | 36 in classrooms; number in training areas to be advised | 10 staff plus 3 maximum in each SIM |
| L01 | 158 | 80 |
| L02 | n/a | 280 |
| L03 | n/a | 132 |

## 5.2 Characteristics of key occupant groups

Occupants in the building will be mainly Qantas employees, including staff of the QGFTC and those attending training. The QGFTC staff members are permanent occupants going to the building as a workplace whilst training attendants are transient occupants who will be in the building for the duration of the training. Characteristics of the occupants are described in Table 5-2.

Table 5-2 – Occupant characteristics

| Characteristic | Description |
|---|---|
| Distribution – Age, Gender, Location | Occupants in the building are considered to be representative of the general workforce population and contain few elderly and no children. Staff members are expected to have normal physical and mental attributes. Occupants may be in any area that is in operation at the time of the fire. Some occupants may be in the SIMs. |
| State of Awareness | Due to the use of the building occupants are expected to be awake and alert. |
| Familiarity - egress routes, group roles, training | Staff members will be regular users and will be familiar with the layout of the building and exit locations. Some staff members will have roles in the emergency organization, such as fire wardens. Staff training may be provided all staff members so that they are aware of the egress provisions and take appropriate actions. |

| **Characteristic** | **Description** |
| --- | --- |
| | Training attendants will not be familiar with the egress routes and exit locations; however they can be inducted and become aware of the egress provisions and emergency procedures. |
| Mobility | Most occupants will be mobile and able to evacuate independently. The proportion of occupants with disability is expected to be significantly lower than that of the general public population. |

# 6 Trial Design

The Trial Design comprises the proposed building design together with fire safety systems. Any aspects of the design not explicitly described under the Performance Solution are to comply with the *deemed-to-satisfy* provisions of the BCA and referenced Australian Standards.

## 6.1 Fire Resistance and Separation

The building will be divided into fire compartments within the limits of Clause C2.2 of the BCA. The four fire compartments are:

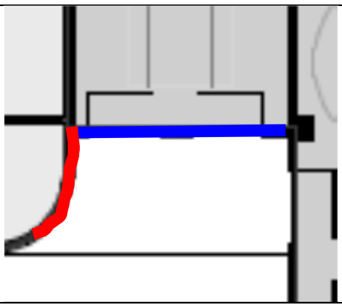
- the EP Hall;
- SIM Hall South, including Level 1 and Level 2 and the entry hall;
- SIM Hall North; and
- Office on Level 3.

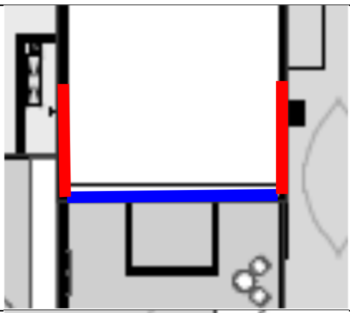
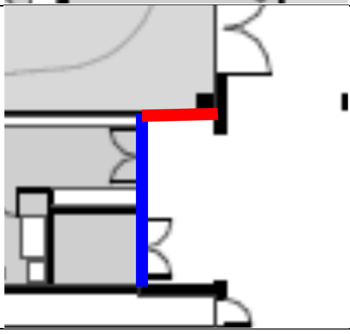
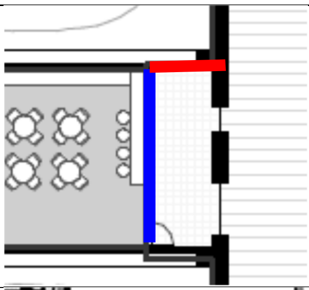
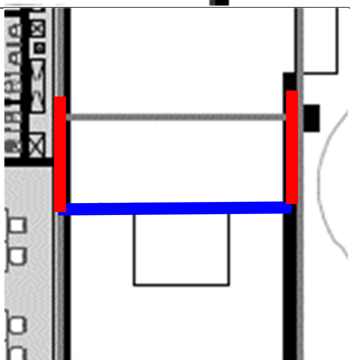
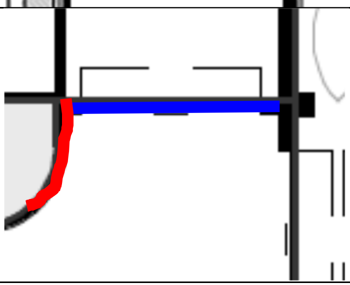
Due to fire compartmentation different types of construction are applied to the EP Hall (Type B) and the SIM Hall (Type A), determined from rise in storey and classification. Fire separation between fire compartments are by fire walls and floors of the same FRL in lieu of a fire wall extending through all levels as per BCA Clause C2.7, which will be subject to Performance Solution. The fire compartments and separation between fire compartments on each level are shown in Appendix C. In the lines of fire separation:

a) Walls must have FRL not less than 120/120/120 (load-bearing) or -/120/120 (non-load-bearing) constructed in accordance with BCA Clause C2.7(a);
b) Doors in the fire wall must be fire doors with FRL not less than -/120/30.
c) The sliding fire door between the EP Hall and the EP Raft Hall is to comply with Clause C3.6;
d) The double leaf doors between the EP Hall and the Entry on Ground Level and Level 1 are horizontal exits and must comply with BCA Clause C3.7.

Protection of openings in external walls of different fire compartments at various junctions will be subject to Performance Solution which permits fire rating external wall of one of the fire compartments on both sides of the wall to prevent fire spread in both directions between the two fire compartments, instead of protecting openings in both fire compartments under Clause C3.3. The methods of protection may not be those in Clause C3.4. The deviations from Clause C3.3 and C3.4 are subject to Performance Solution. Openings affected are identified in Table 6-1.

Table 6-1 Openings in external walls of different fire compartment

| Location | Illustration | Fire compartment and method of protection |
|---|---|---|
| ***Ground Level:*** | | |
| Southern elevation between EP and SIM South fire compartments |  | EP – Fire wall extending 4m south of junction<br>SIM South – no protection |

| | | |
|---|---|---|
| Northern elevation, opening in Entry between EP and Sim South and between SIM North and SIM South |  | EP – Fire wall extending 4m north of junction;<br>SIM North - Fire wall extending 4m north of junction<br>SIM South – no protection |
| Eastern elevation between SIM North and SIM South |  | SIM North - Fire wall extending to eastern elevation of SIM North fire compartment<br>SIM South – no protection |
| ***Level 1:*** | | |
| Eastern elevation between SIM North and SIM South |  | SIM North - Fire wall extending to eastern elevation of SIM North fire compartment<br>SIM South – no protection |
| Northern elevation, opening in Entry between EP and Sim South and between SIM North and SIM South |  | EP – Fire wall extending 4m north of junction;<br>SIM North - Fire wall extending 4m north of junction<br>SIM South – no protection |
| Southern elevation between EP and SIM South fire compartments |  | EP – Fire wall extending 4m south of junction<br>SIM South – no protection |

## 6.2 Smoke separation

In order to prevent smoke spread to more than two levels, smoke separation on Level 2 of the flight training centre is required under the Performance Solution as follows and illustrated in Figure 6-1.

- Between Level 2 teaching areas and the SIM halls; and
- Around the open stair on Level 2.

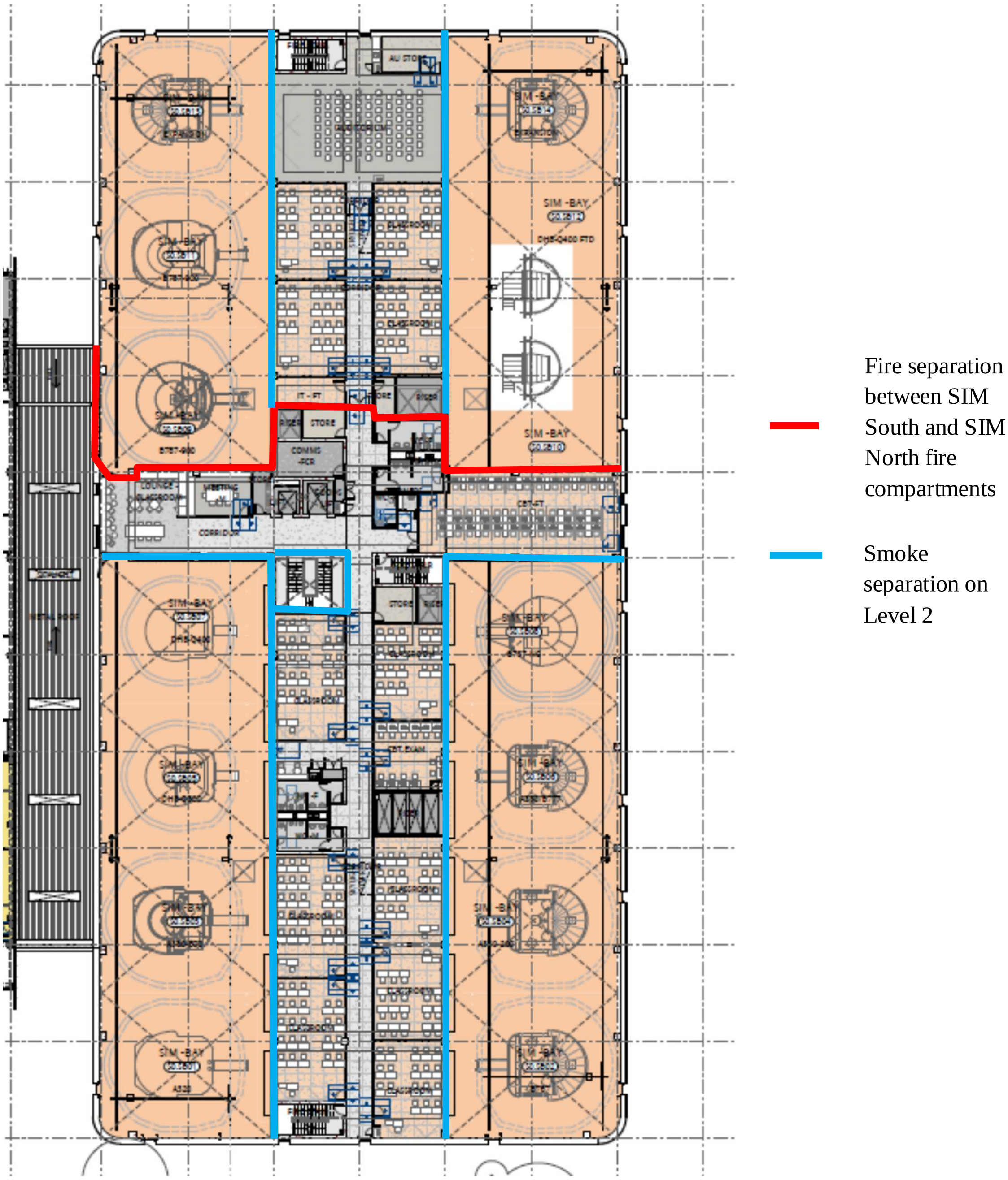



Figure 6-1 Smoke separation between Level 2 and SIM halls

In the lines of smoke separation,

- Walls are to be non-combustible and extend to the underside of Level 3 floor slab or the roof;
- Glazed areas are to be of toughen glass;
- Doorways are to be fitted with smoke doors complying with Specification C3.4;
- Have all openings around penetrations and the junctions of the smoke-proof wall and the remainder of the building stopped with non-combustible material to prevent the free passage of smoke;
- Incorporate smoke dampers where air-handling ducts penetrate the wall;
- Smoke curtains may be used to seal up the two open sides of the open stair on Level 2.

## 6.3 Egress Provisions

The EP Hall will be provided with three open stairs connecting the two levels. On the Ground Level exits will be provided to open space on the north and south sides and through horizontal exit to the entry space. The four-level flight training centre will have three fire isolated stairs, at both northern and southern ends and in the middle. Exits on the Ground Level are from the perimeter of the SIM bays and the entry space. The number of exits and fire isolation where required will comply with the BCA DtS provisions. Aggregate exit width from each level will be no less than that required for the number of occupants.

### *6.3.1 Required stair connecting more than 2 levels not fire isolated*

The northern stair in the EP hall is a required stair which connects Ground Level, Level 1 and the Level 2 plant room and is fire separated on Level 2 only. This is against Clause D1.3 which requires fire isolated stairs where more than 2 levels are connected in buildings not protected by a fire sprinkler system. The stair is subject to Performance Solution.

### *6.3.2 Travel distances*

Travel distances are subject to Performance Solution, including over 20m to Point of Choice (PoC), over 40m to the nearest exit and over 60m between alternative exits via PoC, as follows.

Travel distances to PoC exceeding 20m:

- 26m from the northern office area on Level 3 *(applicable only to the extension option)*
- 28m from the southern office area on Level 3 *(applicable only to the extension option)*
- 25m from the kitchen on Level 2
- 23m from the CBT PT on Level 2
- 26m from Pilot Lounge on Level 1
- 25m from CBT EP on Level 1

Travel distances to the nearest exit exceeding 40m:

- 48m from northern office area on Level 3 *(applicable only to the extension option)*

Travel distances between two alternative exits through the point of choice exceed 60m:

- 78m between central and northern fire stairs on Level 3
- 75m between central and southern fire stairs on Level 3*(applicable only to the extension option)*
- 69m between EP hall exits north and south (to be resolved by swinging fire door into entry lobby and provide horizontal exit)

- 74m between external exits in the SIM bays on Ground Level
- 68m between external exit in SIM bay and central fire stair on Ground Level

### 6.3.3 Egress from SIMs and SIM halls

***SIM evacuation***

Access to a SIM is from the Level 1 gantry via a draw bridge that is supplied with the SIM. The draw bridge will be attached to the gantry and is detached from the SIM when it is in operation. When a SIM is in use there will typically be three occupants: an instructor and two pilot trainees. In rare occasions an instructor may be in the SIM alone. The instructors are familiar with the emergency procedures and are responsible for taking actions in an emergency; trainees are inducted prior to entering the SIM.

Emergency switches are provided within the SIM which when operated will terminate the simulation, restore the SIM to its stationary position and release the draw bridge for the occupants to evacuate the SIM. A secondary means of escape from the SIM is provided in case of draw bridge fault, via an escape ladder that can descend to the Ground Level.

***Width of paths of travel around the SIM envelopes***

Widths of paths of travel to exits within the SIM bays at various locations may be less than 1m if the simulator(s) happen to be in the most stretched position of the full motion envelopes (i.e. the maximum space of possible movement) and fail to restore to the original stationary position at the time of emergency. The potentially reduced widths of paths of travel due to encroachment by the simulators are subject to Performance Solution.

### 6.3.4 Non-required open stair connecting more than two storeys

The open stair in the flight training centre part is not required for egress. It connects four levels, contrary to BCA Clause D1.12 which permits only two levels be connected in buildings not protected by sprinklers. The connection of four levels will be subject to Performance Solution involving fire separation of Level 3 and smoke separation on Level 2 as discussed in Sections 6.1 and 6.2.

## 6.4 Fire Services Systems

### 6.4.1 Firefighting equipment

***Fire hydrants***. The fire hydrant system is to generally comply with Part E1 of the BCA and relevant Australian Standards, except that the fire brigade booster assembly will be located at the rear of the building which faces the main public road (King Street) for site access, after consultation with Fire & Rescue NSW, instead of being in the front of the building within sight of the main entrance as per AS2419.1-2005. Booster location is shown in Figure 6-2. The booster assembly is not in or attached to the external wall; however the distance from the nearest external wall is less than the minimum 10m required in AS2419.1 and is not proposed to be protected by an adjacent fire-rated freestanding wall as per BCA Clause E1.3(b)(i)(C). The external wall fire rated to 3.6m in height above Ground Floor will be relied on to provide protection to the fire hydrant booster assembly.

***Fire hose reels***. Fire hose reels (FHRs) are proposed to be replaced by portable fire extinguishers to cover Class A risks where FHRs are required under DtS provisions.

***Fire suppression***. No automatic sprinkler system is proposed as the fire compartment sizes are within limits under Clause C2.2. The hydraulic driven SIMs will have local water mist suppression system dedicated to control fires involving the hydraulic motion system under the SIM. The water mist system will be activated by beam detectors. Both the beam detector and the water mist system are supplied by the manufacturer of the SIMs.

***Portable fire extinguishers*** are to be provided to cover Class A risks throughout the building in the place of fire hose reels in addition to extinguishers covering other risks in accordance with BCA Clause E1.6 and AS2444-2006.

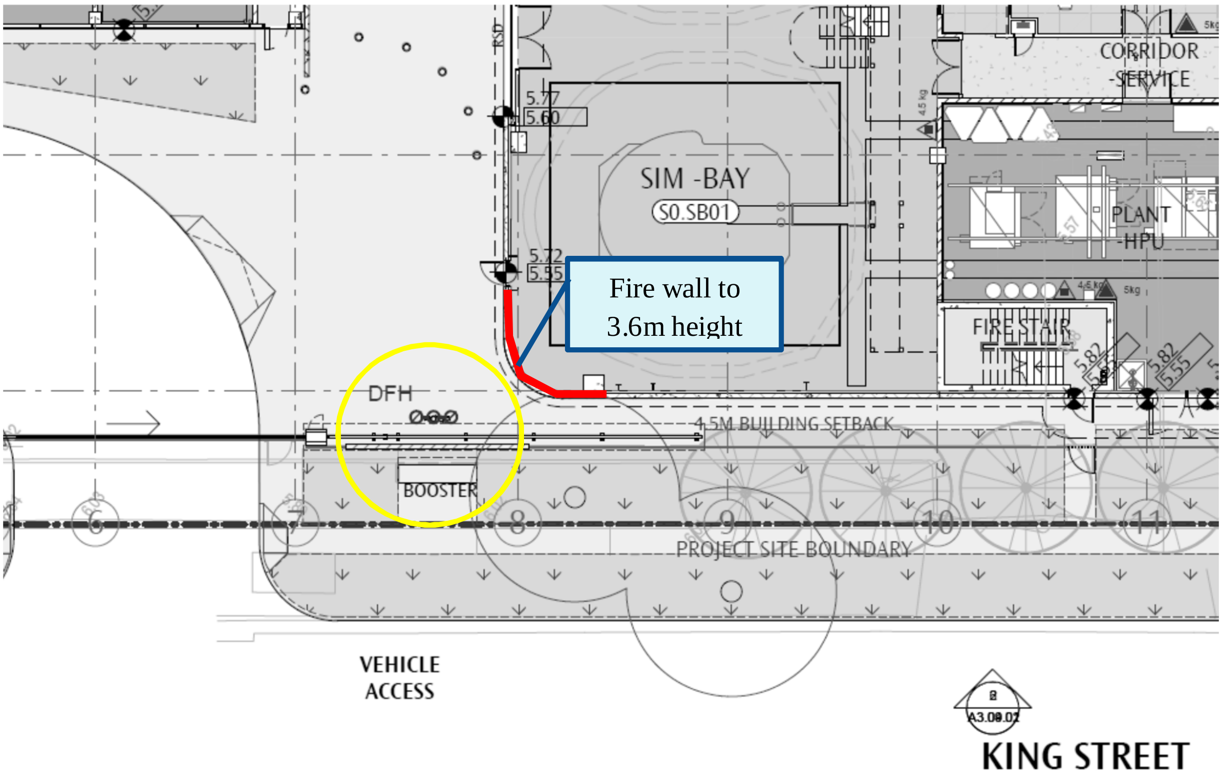



Figure 6-2 Fire brigade booster location

### 6.4.2 Smoke hazard management

***Fire Detection System***

An automatic smoke detection and alarm system complying with Clause 4 of Specification E2.2a and AS1670.1-2015 is to be installed throughout the building, with the following variations due to unique building usage.

- The SIMs have air sampling (VESDA) smoke detectors within the simulator chamber which are provided by the supplier, i.e. not due to requirement of the building project. The VESDA detectors in an individual SIM will be isolated when theatrical smoke is used in simulation, as is the case in the existing facility.

- In the SIM halls, multisensory detectors are proposed to have smoke and heat detection functions. Upon activation of smoke detection, alert signals are to be issued to SIM IT monitoring panels; activation of heat detection is to initiate emergency procedures, evacuation alarms and notification to the fire brigade.
- The hydraulic motion systems of the hydraulic SIMs are provided with beam detector to detect fire involving the hydraulic system under the SIM and activate the water mist fire suppression.
- In the open EP Hall, smoke detectors and linear heat detection devices are proposed. Smoke detectors are to be isolated when theatrical smoke is used in the evacuation emergency simulation to prevent false alarms.
- Point type heat detectors are to be installed within the cabin evacuation emergency trainers in the EP Hall to prevent delay of fire detection due to fire/smoke being shielded, especially when the smoke detectors are isolated.
- Smoke detectors are exempted above the pool in the EP hall due to difficult access for maintenance and that a fire is extremely unlikely to initiate and grow in the pool. Smoke detectors are to be installed around the pool. The horizontal distance between the edges of the pool and the nearest row of detectors must not exceed half of the maximum distance allowable between detectors.

***Smoke Exhaust***

The provision of smoke exhaust system required due to Class 9b fire compartments exceeding 2000m$^2$ is subject to Performance Solution. Smoke exhaust is not proposed in the SIM halls due to smoke separation of Level 2 and low population on Ground Level and Level 1.

It is proposed to install smoke exhaust in the EP Hall only to maintain tenable conditions for occupants on both levels. The exhaust rate is to be 40m$^3$/s in accordance with Figure 2.1 of Specification E2.2b based on smoke layer at 6m above Ground Level (2m above Level 1) and 5MW design fire size in Class 9 building without sprinklers. Make-up air may be supplied mechanically with a supply rate of 32m$^3$/s or via automated opening with clear area not less than 12.8m$^2$ at low level.

### *6.4.3 Visibility in an Emergency, Exit Signs and Warning Systems*

Emergency lighting and exit signs are to comply with Clause E4.4, E4.5, NSW E4.6, E4.8 and E4AS2293.1 - 2005.

Occupant warning is to be provided as part of the smoke detection system as per Clause 7 of Specification E2.2a and AS1670.1.

## 6.5 Part G3

The SIM halls connect three levels, thus are technically atria and triggers Part G3 requirements under DtS provisions. It is proposed on performance basis that Part G3 is not applied. As Level 2 is smoke separated from the SIM halls and the lower levels, only two levels are connected by the SIM halls in evacuation stage.

## 6.6 Commissioning and Maintenance Requirements

All fire safety systems maintenance and isolation should be in accordance with AS1851:2012.

## 6.7 Performance Solution

The deviations from BCA DtS provisions are detailed in Table 6-2, in the context of the relevant BCA DtS Clauses, Performance Solutions and the approach of assessment as per BCA Part A2.

Table 6-2– **Building Items Subject to Performance (Alternative) Solutions**

| Item No. | DtS Clause | Description | Proposed under Performance Solution | Performance Requirements | Verification Methods as per Clause A2.2 (2) |
|---|---|---|---|---|---|
| **1.** | **C2.7** | Fire compartment separation | Fire separation between fire compartments in generally is not by a fire wall extending through all levels; fire walls and floor slabs together form fire barriers to prevent fire spread between fire compartments. | CP2 | (b) (ii) other verification methods acceptable to the certifying authority |
| **2.** | **C3.3 & C3.4** | Protection of openings in external walls of different fire compartments | Fire resistance levels to be provided to external walls of one of the adjacent fire compartments from both side of the wall, so that fire spread cannot occur in either direction. | CP2 | |
| **3.** | **D1.3** | Required stair connecting 3 storeys not fire isolated | The northern stair in the EP hall is a required stair which connects Ground Level, Level 1 and the Level 2 plant room and is fire separated on Level 2 only. | DP5 | (b) (ii) other verification methods acceptable to the certifying authority |
| **4.** | **D1.4** | Exit travel distances to a point of choice between available exits and to the nearest exit | Travel distances to PoC exceeding 20m:<br>• 25m from the kitchen on Level 2<br>• 23m from the CBT PT on Level 2<br>• 26m from Pilot Lounge on Level 1<br>• 25m from CBT EP on Level 1<br>• 28m from northern office area on Level 3[a]<br>• 28m from southern office area on Level 3[a]<br><br>Travel distances to the nearest exit exceeding 40m:<br>• 48m from northern office area on Level 3[a] | DP4, EP2.2 | (b) (ii) other verification methods acceptable to the certifying authority; and<br>(d) comparison with the *deemed-to-satisfy* provisions |
| **5.** | **D1.5** | Distance between alternative exits | Travel distances between two alternative exits through the point of choice exceed 60m:<br>• 78m between central and northern fire stairs on Lv 3<br>• 75m between central and southern fire stairs on Lv 3 | DP4, EP2.2 | (b) (ii) other verification methods acceptable to the certifying authority |

| | | | | | |
|---|---|---|---|---|---|
| | | | • 74m between external exits in the SIM bays on Ground Level<br>• 68m between external exit in SIM bay and central fire stair on Ground Level | | |
| **6.** | **D1.6** | Dimensions of path of travel to an exit | A path of travel to an exit may be encroached and have less than 1m width if simulators stop at position closest to the path at the time of emergency. | DP6 | (b) (ii) other verification methods acceptable to the certifying authority |
| **7.** | **D1.12** | Open stair connecting four levels | The central, non-required stair connects four levels. It is proposed to smoke separate Level 2 and fire separate Level 3, so that the open stair connects only two levels in fire mode during the evacuation stage. | CP2, EP2.2 | (b) (ii) other verification methods acceptable to the certifying authority |
| **8.** | **E1.3, AS2419. 1** | Location of fire brigade booster assembly | Fire brigade booster assembly will be located<br>• at the rear of the building which faces the main public road (King Street) for site access after consultation with Fire & Rescue NSW.<br>• less than the minimum 10m from the external wall and is not proposed to be protected by an adjacent fire-rated freestanding fire rated wall. The external wall fire rated to 3.6m in height above Ground Floor will be relied on to provide protection to the fire hydrant booster assembly. | EP1.3 | (b) (ii) other verification methods acceptable to the certifying authority |
| **9.** | **E1.4** | Fire hose reels | Fire hose reels (FHRs) are proposed to be replaced by portable fire extinguishers to cover Class A risks where FHRs are required under DtS provisions. | EP1.1 | (d) comparison with the *deemed-to-satisfy* provisions |
| **10.** | **E2.2** | Smoke exhaust | Smoke exhaust is to be provided in the EP Hall.<br>Smoke exhaust is not proposed in the SIM Hall, due to smoke separation of Level 2 and low population on Ground Level and Level 1. | EP2.2 | (b) (ii) other verification methods acceptable to the certifying authority |
| **11.** | **Part G3** | Atrium provisions | Part G3 will not be applied due to unique building design and usage and smoke separation of Level 2 floor space from the SIM halls. | EP1.4, EP2.2 | (b) (ii) other verification methods acceptable to the certifying authority |

Note: a. *applicable only to the Level 3 extension option*

# 7 Approaches and methods of analysis

## 7.1 Approach of analysis as per IFEG

The evaluation will involve the following sub-systems as per IFEG Part 1:

- *Sub-system B* Smoke Development and Spread and Control
- *Sub-system C* Fire Spread and Impact and Control
- *Sub-system D* Fire Detection, Warning and Suppression
- *Sub-system E* Occupant Evacuation and Control
- *Sub-system F* Fire Services Intervention

The approach of analysis will be:

1. *absolute* and *comparative*. A combination of absolute and comparative analysis will be vel distances will be analyzed, and the results will be matched using the agreed acceptance criteria against the acceptance criteria without comparison to a DtS benchmark design. The fire hydrant and fire hose reel deviations will be compared with DtS provisions.

2. *qualitative* and *quantitative* combined. Smoke spread modelling will be undertaken for assessing conditions for evacuation on the level of fire origin and the level above to obtain the Available Safe Evacuation Time (ASET). Egress analysis will be conducted to estimate time required for occupants to evacuate the afore mentioned levels, i.e. the Required Safe Evacuation Time (RSET). The quantitative analysis will enable comparison of ASET and RSET for assessing occupant safety.

   Qualitative assessment will be undertaken for the deviations in relation to fire hydrant and fire hose reels system.

3. *deterministic*. The analysis will not be based on probabilities of fire occurrence and system failure. A fire is assumed to have occurred and the consequences will be assessed.

## *7.2 Acceptance Criteria*

In accordance with the IFEG[1],

*When a fire engineering design is proposed, acceptance criteria must be developed in order to analyse the outcome of the design. The relationship between the acceptance criteria and the relevant Performance Requirements is often a matter of engineering judgement and therefore can vary between individual practitioners and from project to project. This variation can be minimised by the involvement of all stakeholders in the setting of the acceptance criteria that will also form an important part of the fire engineering brief.*

### *7.2.1 Tenability Criteria for Occupant Life Safety*

With reference to the SFPE handbook[2], the tenability criteria for occupant life safety to be applied are summarised in Table 7-1 and discussed further below.

Table 7-1 Occupant life safety criteria

| TENABILITY CRITERIA | DESCRIPTION |
|---|---|
| **Air/smoke temperature** | • Air/smoke temperature reaches 183°C (approximately equal to 2.5 kW/m$^2$) consistently across the entire fire enclosure at any height; or<br>• Significant pockets of air/smoke reaches 100°C in the vicinity of the egress path at a height of 2.1 m. |
| **Visibility** | • Substantial accumulation of stagnant smoke is formed below 2.1 m in the vicinity of the egress path such that visibility drops to be less than 10 m (i.e. an optical density of 0.1 m$^{-1}$) in path of travel, or less than 5m where occupants are queuing at exits. |

***Smoke layer height < 2.1m***

The risk of inhalation of potentially toxic combustion gases is minimised when the smoke layer is above head height during occupant evacuation. For the purposes of building design, a safe smoke layer height of 2.1 will be deemed to be acceptable. Once the smoke layer height is below 2.1m, the conditions become untenable when one or more of the following conditions is exceeded.

- Smoke temperature exceeds 100°C[13]. The tolerance time under medium humidity conditions is given by the following equation:

  $$t_1[min] = 2 \times 10^{31} \times T^{-16.963} + 4 \times 10^{8} \times T^{-3.7561}) \qquad (1)$$

  The above equation leads to a tenable time in excess of 10 minutes for an exposure temperature of 100°C.

- Smoke Optical Density

  The minimum acceptable visibility from a small enclosure is 5m (0.2 optical density/m), which, for irritant smoke, is that at which people behave as if in darkness. In large enclosures, occupants require much greater visibility to orient themselves and therefore a minimum visibility is required to be 10m (0.1 optical density/m)[13]. For the current analysis, a minimum visibility of 10m will be used for travelling in egress routes towards exits. Where occupants are queuing at an exit, a minimum visibility of 5m (0.2 optical density/m) will be used.

- Exposure to toxic gases of combustion

  It has been observed in several studies that Carbon Monoxide (CO) concentration is critical in determining the tenability in a smoky environment such as that obtained in a fire scenario. The International Fire Engineering Guidelines1 recommends the use of CO concentration as one of the acceptance criteria at 1400ppm (0.00168 kg/m$^3$). However, it has been observed that the mixture of asphyxiant gases (CO, $CO_2$, Low $O_2$ and HCN) is approximately additive and the tenability for total inhalation of asphyxiant gases can be related to optical density of smoke. It is recommended that the level of toxic products (asphyxiants and irritants), are unlikely to reach limiting levels for up to 30 min in situations where the smoke optical density does not exceed 0.1/m (or 10m visibility).

***Radiant Heat Impact on Occupants***

The maximum safe exposure level, for a duration greater than 5 min, is 2.4kW/m² [32] and therefore this radiation exposure level will be used as the acceptance criteria for safety during occupant evacuation. For flux greater than or equal to 2.5kW/m², the tolerance time for heat radiation is given by:

$$t_m = \frac{1.33}{q^{1.333}} \tag{2}$$

Where:

$t_m$ = time (min) to incapacitation due to skin pain

q = the radiant heat flux (kW/m²).

Radiant heat flux may reach 2.5kW/m² when smoke temperature is 183°C; thus the radiant heat criterion is converted to temperature of 183°C for easier assessment as modelling results provide detailed information on temperatures.

### 7.2.2 Fire Fighter Life Safety Criteria

The following acceptance criteria are extracted from the Manual of the AFAC Fire Brigade Intervention Model[3] for Available Safe Intervention Time (ASIT); (Section 6, pp.87):

> *The following results, relative to height of 1500mm above floor level, apply:*
>
> *Routine Condition*
> *Elevated temperatures, but not direct thermal radiation*
> *Maximum Time: 25 minutes*
> *Maximum Air Temperature: 100°C (in lower layer)*
> *Maximum Radiation: 1kW/m²*
>
> *Hazardous Condition*
> *Where firefighters would be expected to operate for a short period of time in high temperatures in combination with direct thermal radiation*
> *Maximum Time: 10 minutes*
> *Maximum Air Temperature: 120°C (in lower layer)*
> *Maximum Radiation: 3 kW/m²*
>
> *Extreme Condition*
> *These conditions would be encountered in a snatch rescue situation or a retreat from a flashover*
> *Maximum Time: 1 minute*
> *Maximum Air Temperature: 160°C (in lower layer)*
> *Maximum Air Temperature: 280°C (in upper layer)**
> *Maximum Radiation: 4 - 4.5 kW/m²*
>
> *Critical Conditions*
> *Firefighters would not be expected to operate in these conditions, but could be encountered.*
> *Considered to be life threatening*
> *Time: < 1 minute*
> *Air Temperature: > 235°C (in lower layer)*

*Radiation: > 10 kW/m²*

For the purpose of this assessment, it is required that the condition is not more onerous than the Hazardous Condition when the first arrived fire crew gets ready to start firefighting, i.e. at the time the first arrived fire crew finishes initial setup protection predicted by the FBIM, maximum temperature in the lower layer is less than 120°C, and the maximum radiation is less than 3 kW/m².

### 7.2.3 Factors of safety

Factors of safety are quantified safety margins. The IFEG[1] states:

*The magnitude of the factors of safety adopted should be based on a consideration of:*

- *the extent of redundancy in the trial design*
- *the reliability of the various components of the fire safety system*
- *the analysis methods used*
- *the assumptions made for the analysis*
- *the results of an uncertainty analysis*
- *the acceptance criteria used*
- *the consequences of a fire.*

*As some of the above may not be quantified until the analysis has been completed, actual numerical values for the factors of safety may not be determined at the FEB stage. In such cases the FEB may give guidance on acceptable values and the fire engineer will need to justify the actual values used in the report.*
*Factors of safety should only be applied at the end of a calculation sequence, and not throughout the analysis steps because this could lead to over conservative outcomes.*
……
*For the purposes of sensitivity studies, less rigorous factors of safety may be appropriate in order to avoid overly conservative outcomes.*

For the ASET/RSET and ASIT/RSIT comparison approach, the factor of safety is defined as the ratio of the available time over the required time. The following factors of safety are selected for various fire scenarios and the subjects of the assessment.

- Factor of safety for occupant evacuation: ASET/RSET ≥ 1.5
- Factor of safety for fire brigade intervention: $ASIT_{TEMP}/RSIT \geq 1.5$

The FEB is to be distributed to stakeholders for agreement prior to proceeding with the FER. The above mentioned safety factors or other values agreed by stakeholders will be regarded as appropriate and adopted in the assessment.

### 7.2.4 Acceptance Criteria of the Performance Solution

The acceptance criteria of the Performance Solution items in Table 6-2 are summarized as follows.

- Fire spread between fire compartments is unlikely to occur due to
    - fire walls not carrying through all levels; or

    - via openings in external walls.
- For extended travel distances and smoke hazard:
    - Occupants are not more likely to be trapped by a fire than in the case of a DtS benchmark design.
    - Path of travel is available at any time.
    - Tenable conditions are maintained for occupant evacuation and fire brigade intervention, demonstrated by ASET/RSET and ASIT/RSIT comparison.
- The open stair will not result in smoke spread to more than two levels.
- For fire extinguishers in lieu of FHRs: occupants undertaking first aid firefighting are not exposed to more hazardous conditions compared to the DtS benchmark design with full FHR coverage.
- For fire hydrant system: the system design is acceptable to FRNSW.

## 7.3 Smoke movement model for Assessment

Smoke movement modelling will be undertaken using NIST Fire Dynamics Simulator 6[4] ('FDS' hereafter). FDS is a computational fluid dynamics (CFD) model for fire spread and smoke movement. The software solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow with an emphasis on smoke and heat transport from fires.

FDS model requires that the room or building of interest be divided into small rectangular control volumes or computational cells. FDS computes the density, velocity, temperature, pressure and species concentration of the gas in each cell based on the conservation laws of mass, momentum, and energy to model the movement of fire gases.

The output of FDS simulations are presented and viewed in Smokeview[5], a software purposely developed to display FDS modelling results.

# 8 Design Fire Scenarios and Design Fires

## 8.1 Fire Hazards and Preventative and Protective Measures Available

Table 8-1 tabulates potential ignition sources and fire hazards of significance that are likely to be encountered in the building, and preventative and protective measures to mitigate the risk.

Table 8-1 – Potential ignition sources and fire hazards

<table>
<tr><th>Location</th><th>Ignition Sources & Fire Hazards</th><th>Mitigation Measures</th></tr>
<tr><td>FTC – SIM halls</td><td><u>Ignition Sources</u><br>Electrical fault<br>Oil spillage (SIM South only)<br><br><u>Fuel Load</u><br>SIMs (devices, seats)<br>Auxiliary equipment<br>Cables, pipes etc.<br>Hydraulic oil (SIM South only)</td><td rowspan="7"><u>Building Management</u><br>Chemical storage in accordance with AS1940 – large volume in fire isolated storage; small volume in cabinets<br>Regular maintenance of essential services<br><br><u>Fire Safety Systems</u><br>Fire detection system<br>Fire hydrants<br>Water mist suppression of hydraulic system under SIMs<br>Exit signage and emergency lighting<br>Occupant warning system<br><br><u>Design features</u><br>Fire compartmentation as described in Section 6.1<br>Smoke separation as described in Section 6.2<br>Oil trenches with solid steel cover to contain oil pipes and cables and<br><br><u>Emergency Management</u><br>Emergency plan to AS3745-2010<br>Training and safety induction</td></tr>
<tr><td>FTC – IT rooms</td><td><u>Ignition Sources</u><br>Electrical fault<br><br><u>Fuel Load</u><br>IT Equipment<br>Lining materials<br>furniture</td></tr>
<tr><td>FTC - Offices</td><td><u>Ignition Sources</u><br>Electrical fault<br><br><u>Fuel Load</u><br>Lining materials<br>Furniture<br>Office equipment (computers, printers etc.)<br>Paper</td></tr>
<tr><td>FTC – Classrooms</td><td><u>Ignition Sources</u><br>Electrical fault<br><br><u>Fuel Load</u><br>Lining materials<br>Furniture</td></tr>
<tr><td>EP - Hall</td><td><u>Ignition Sources</u><br>Electrical fault<br><br><u>Fuel Load</u><br>Equipment</td></tr>
<tr><td>EP – Classrooms</td><td><u>Ignition Sources</u><br>Electrical fault<br><br><u>Fuel Load</u><br>Lining materials<br>Furniture</td></tr>
<tr><td>EP Raft hall</td><td><u>Ignition Sources</u><br>Electrical fault<br><br><u>Fuel Load</u><br>Rafts</td></tr>
</table>

## 8.2 Design fire scenarios

The fire scenarios are selected to represent the worst credible, thus most challenging, scenarios for the features under assessment.

Fire Scenario 1. A fire in SIM Bay 07 of the SIM South fire compartment on Ground floor,

Fire Scenario 2. A fire in SIM Bay 11 of the SIM South fire compartment on Ground floor, involving electrical equipment as main fuel, thus will not grow as fast as Fire Scenario 1. This scenario is to be used for assessing smoke filling in the smaller SIM halls.

Fire Scenario 3. A fire in the middle IT room on Ground Level, for assessing the smoke separation strategy and the potential of smoke spread to more than two levels.

Fire Scenario 4. A fire on Level 3 in the south office area, for assessing extended travel distances between alternative exits via the point of choice.

Fire Scenario 5. A fire in the fuselage simulator in the EP hall, for assessing smoke exhaust in the EP hall

## 8.3 Fire growth rates

Most fires that do not involve flammable liquids, gases or lightweight combustibles such as polymeric foams grow relatively slowly in the initial stage, or so-called incubation stage. For conservatism and due to uncertainties of fire ignition, the incubation stage is excluded in fire engineering assessment. As the fire increases in size, the rate of fire growth accelerates. This rate of fire growth is generally expressed in terms of an energy release rate. For design purposes, an exponential or power-law rate of energy release is often used. The most commonly used exponential relationship between time and heat release rate is the time-squared or *t-squared* fire, as defined in NFPA Standard 204[6] and referenced in the International Fire Engineering Guidelines[1]. In such a fire, the rate of heat release is given by the expression:

$$\dot{Q} = \dot{Q}_g\left(t/t_g\right)^2$$

where $\dot{Q}$ is the heat release rate, MW; $\dot{Q}_g$ is a constant, 1.055 MW; $t$ is time from ignition of the fire, $s$, $t_g$ is the growth time (seconds) for the fire to reach a heat output of 1.055 MW, $s$.

BSI PD 7974-1:2003[7] recommends medium fire in offices, which typically contain office furniture, computers and accessories, paper etc. This fire growth rate is also considered appropriate for classroom and IT room.

In the SIM hall, an ultra-fast fire growth is selected to represent the rapid increase of fire size in the initial stage assuming the fire starts with combustion of leaked hydraulic oil. Due to the water mist suppression and trenches with solid steel cover to contain oil leaked from pipework before it reaches under the SIM, the ultra-fast growth rate cannot be sustained. Conservatively assume the beam detector is activated when the fire is 1MW, in which case the temperature in the middle of the fire plume would exceed 500°C in height range of 1~2m above the floor in the 'view' of the beam detector; the fire then turns to medium growth rate as fuel outside the targeted area is ignited.

## 8.4 Design fires

As the building will not have sprinkler protection, the fire will not be automatically controlled, although in the case of a fire underneath the hydraulic SIMs in the SIM South fire compartment the water mist suppression is considered to slow down fire growth rather than control the fire. The fires are assumed to keep growing in the assessed timeframe.

The quantified design fires are summarized in Table 8-2. The locations of the design fires are shown in Figure 8-1 and 8-2.

Table 8-2 Summary of design fires

| DESIGN FIRE NUMBER | LOCATION OF FIRE | FIRE GROWTH | FIRE SIZE AT 20 MINUTES |
|---|---|---|---|
| **1** | SIM Bay 07 floor | Ultra-fast turning to medium | 16.8MW |
| **2** | SIM Bay 11 floor (no hydraulic oil) | Medium | 16MW |
| **3** | Middle IT room Ground Level | Medium | 16MW |
| **4** | Level 3 office | Medium *t-squared* fire | 16MW |
| **5** | Fuselage in EP hall | Medium *t-squared* fire | 16MW |

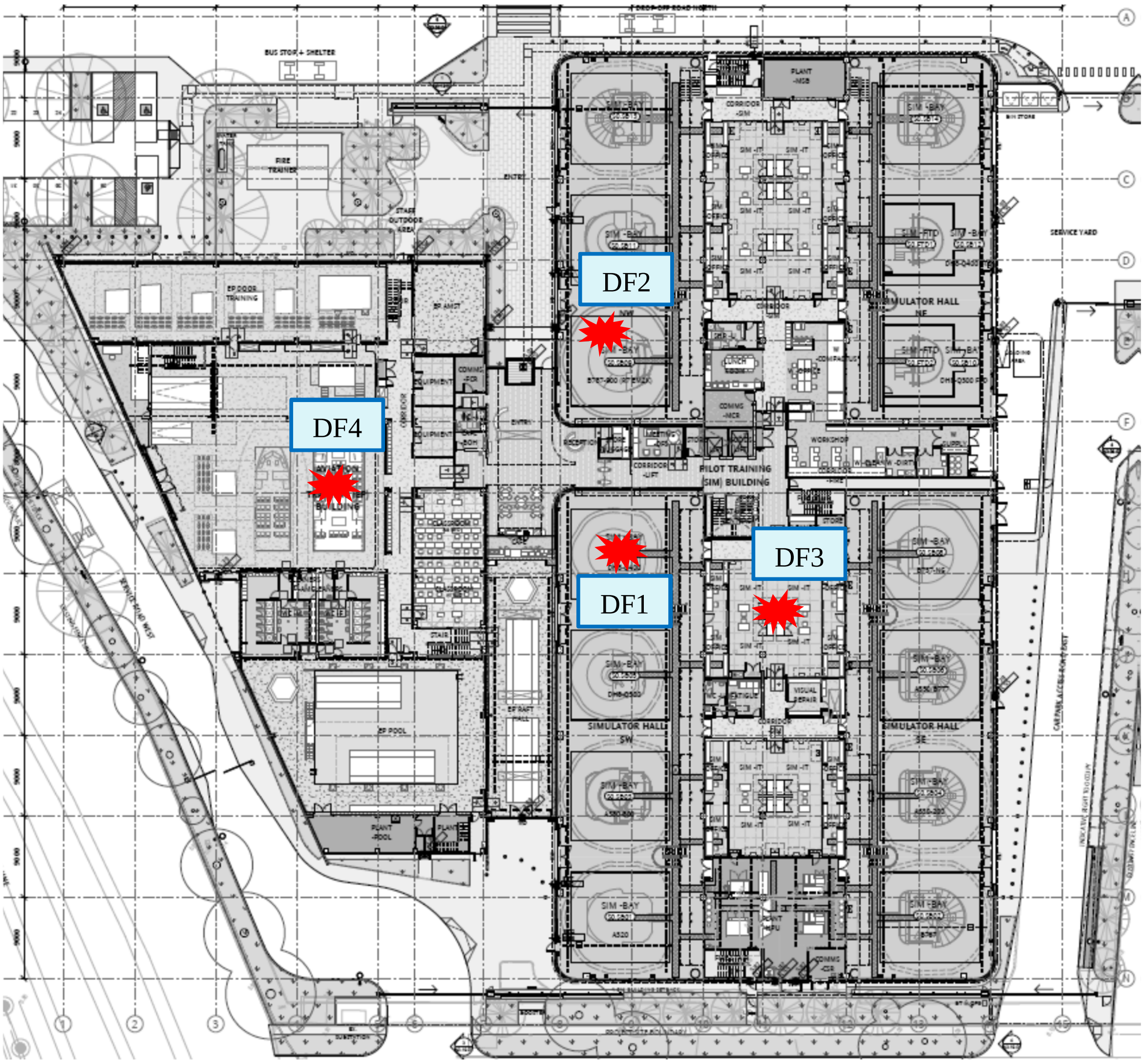



Figure 8-1 Locations of design fires – Ground Level

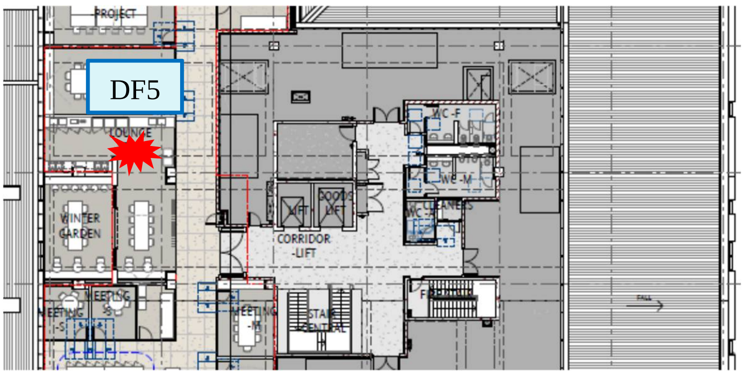


Figure 8-2 Location of design fire –Level 3

# 9 Conclusion

This Fire Engineering Brief (FEB) involves development and agreement of an appropriate methodology, format and trial concept design to enable preparation of the Fire Engineering Report (FER), in accordance with the International Fire Engineering Guidelines. In conjunction with consultation of relevant stakeholders, this document will form the basis for the fire safety analysis to be undertaken in the next stage to prepare the fire engineering report.

# APPENDIX A GLOSSARY AND ABBREVIATIONS

## FIRE ENGINEERING GLOSSARY

| Term | Definition |
|---|---|
| Deemed-to-Satisfy Solution | *A method of satisfying the Deemed-to- Satisfy Provisions.* |
| Deemed-to- Satisfy Provisions | *Provisions that are deemed to satisfy the Performance Requirements.* |
| Effective height | *The vertical distance between the floor of the lowest storey included in the calculation of rise in storeys and the floor of the topmost storey (excluding the topmost storey if it contains only heating, ventilating, lift or other equipment, water tanks or similar service units).* |
| Fire resistance level | *The grading periods in minutes determined in accordance with Schedule 5 of the BCA, for the following criteria –*<br>*(a) Structural adequacy; and*<br>*(b) Integrity; and*<br>*(c) Insulation,*<br>*And expressed in that order.* |
| Performance Requirement | *A requirement which states the level of performance which a Performance Solution or Deemed-to-Satisfy Solution must meet.* |
| Performance Solution | *A method of complying with the Performance Requirements other than by a Deemed-to-Satisfy Solution.* |
| Rise in storey | *The greatest number of storeys calculated in accordance with C1.2 of the BCA.* |
| Type of Construction | *Type of fire-resisting construction of a building determined in accordance with C1.1 of the BCA. Type A is the most fire-resisting and Type C is the least fire-resisting.* |

## ABBREVIATIONS

| Acronym | Definition |
|---|---|
| BCA | *National Code of Construction, Volume One, Building Code of Australia 2019* |
| DtS | *Deemed – to - satisfy* |
| EP&A Act | *Environmental Planning and Assessment Act 1979* |
| EP&A Regulation | *Environmental Planning and Assessment Regulation 2000* |
| FRL | *Fire resistance level* |
| F&R NSW | *Fire and Rescue NSW* |
| NSW | New South Wales |

| Acronym | Definition |
| --- | --- |
| PoC | Point of Choice, a point from which travel in different directions to 2 exits is available. |
| Qantas | Qantas Airways Limited |
| QGFTC | Qantas Group Flight Training Centre |
| SIM | Full Motion Flight Simulators |
| sqm | Square Metres |
| | |

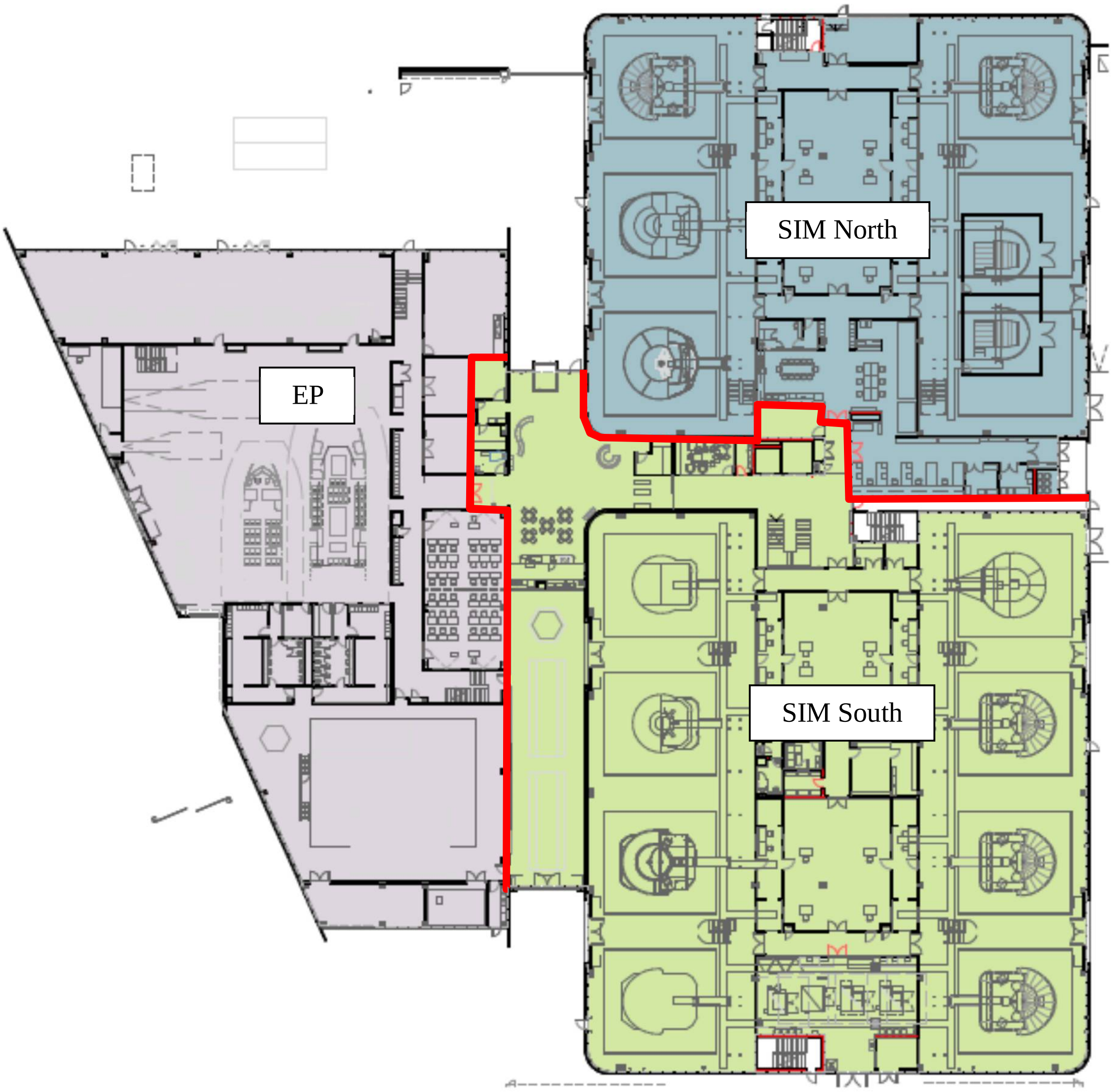
# APPENDIX B Schedule of Provided Population

01. Schedule – Population

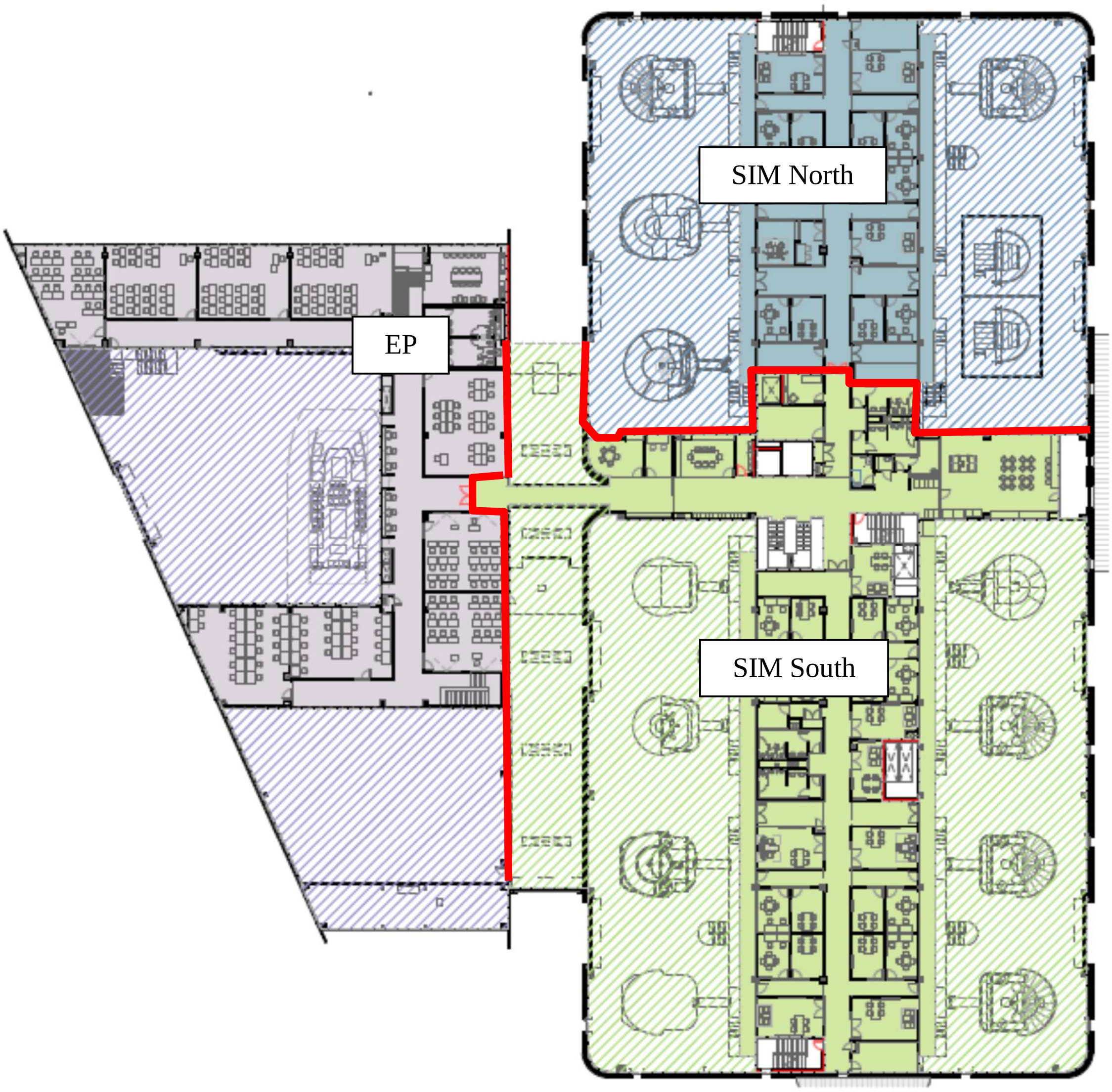
| | | | | | | | | | | MALE | | | FEMALE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | loading | /floor | *Population* | Notes | PAN | URINAL | BASIN | PAN | BASIN |
| | STAFF | LEVEL 4 ADMIN | | | | 100% | | | | | | | | |
| | SF&CO | Commercial Operations | 14 | 16 | | | | | | | | | | |
| | | Simulator Facilities | 2 | | | | | | | | | | | |
| | Training and Checking | Pilot Training | 31 | | | | | | | | | | | |
| | | Aviation Safety Training | 34 | 79 | | | | | | | | | | |
| S-L3~~4~~ | | Flight Training Support | 14 | | *122* | 122 | 122 | 132 | | 4 | 3 | 3 | 5 | 3 |
| | Workforce Planning | Flight Training Scheduling | 21 | 21 | | | | | | | | | | |
| | Third Party | Qantaslink | 4 | 6 | | | | | | | | | | |
| | | Jetstar | 2 | | | | | | | | | | | |
| | STAFF | GROUND FLOOR | | | | 100% | | | | | | | | |
| | SF&CO | Simulator Facilities | 8 | 10 | 10 | 10 | 10 | | 4 Staff x Double shift | 1 | 0 | 1 | 1 | 1 |
| S-L0~~1~~ | Cafe | | 2 | | | | | | | | | | | |
| | STUDENTS | AST | | | | 100% | | | | | | | | |
| | Classroom 01 | | 18 | | | | | | | | | | | |
| E.L0~~1~~ | Classroom 02 | | 18 | | | | 36 | | | | | | | |
| | Classroom 03 | | 18 | | | | | | | | | | | |
| | Classroom 04 | | 18 | | | | | | Same students assumed to be in classrooms as using EP Hall, Door Trainers, Pool, Rafts, Equipment Room, Security/AV Med, Fire Trainer? | | | | | |
| | Classroom 05 | | 18 | 162 | | | | | | | | | | |
| | Classroom 06 | | 18 | | 194 | 194 | | | | 3 | 2 | 3 | 5 | 3 |
| E.L1~~2~~ | Classroom 07 | | 18 | | | | 158 | | | | | | | |
| | Classroom 08 | | 18 | | | | | | | | | | | |
| | Classroom 09 | | 18 | | | | | | | | | | | |
| | CBT-01 | | 16 | 32 | | | | | | | | | | |
| | CBT-02 | | 16 | | | | | | | | | | | |
| | STUDENTS | PILOT TRAINING | | | | 80% | | | | | | | | |
| | FFS | Incoming | 28 | 56 | | | | | 14 FFS x 2 Students | | | | | |
| | | Outgoing | 28 | | | | 80 | | Instructors included under Admin | | | | | |
| S.L1~~2~~ | IPT | Incoming | 22 | 44 | | | | ~~530~~554 | 11 x 2 Students | | | | | |
| | | Outgoing | 22 | | | | | | Instructors included under Admin | | | | | |
| | Classroom 01 | | 18 | | | | | | | | | | | |
| | Classroom 02 | | 18 | | | | | | | | | | | |
| | Classroom 03 | | 18 | | | | | | | | | | | |
| | Classroom 04 | | 18 | | | | | | | | | | | |
| | Classroom 05 | | 18 | | ~~420~~450 | ~~336~~360 | | | | 4 | 3 | ~~4~~5 | 7 | ~~4~~5 |
| | Classroom 06 | | 18 | | | | | | | | | | | |
| | Classroom 07 | | 24 | 260 | | | | | | | | | | |
| S.L2~~3~~ | Classroom 08 | | 24 | | | | ~~256~~280 | | | | | | | |
| | Classroom 09 | | 24 | | | | | | | | | | | |
| | Classroom 10 | | 18 | | | | | | | | | | | |
| | Classroom 11 | | 18 | | | | | | | | | | | |
| | CBT-01 | | 32 | | | | | | | | | | | |
| | CBT-Exam | | 12 | | | | | | | | | | | |
| | Auditorium | | ~~60~~90 | ~~60~~90 | | | | | Expansion | | | | | |
| | **TOTAL** | | | | ~~746~~776 | | | ~~662~~686 | | **12** | **8** | **~~11~~12** | **18** | **~~11~~12** |

S1822 QANTAS GROUP FLIGHT TRAINING | DESIGN BRIEF – SCHEDULES | Version 1.0 DRAFT 3 | 8

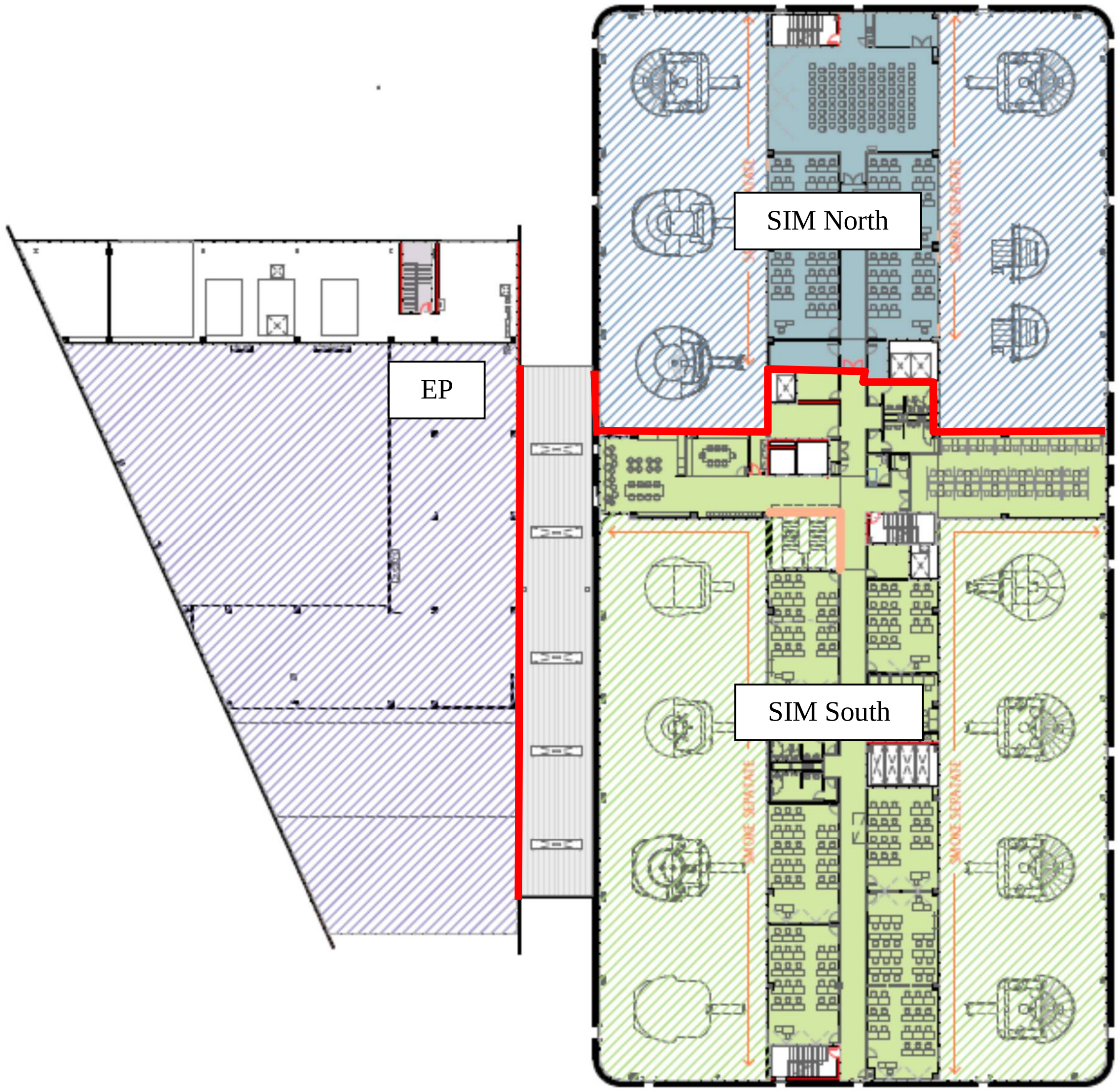
## APPENDIX C FIRE COMPARTMENTS



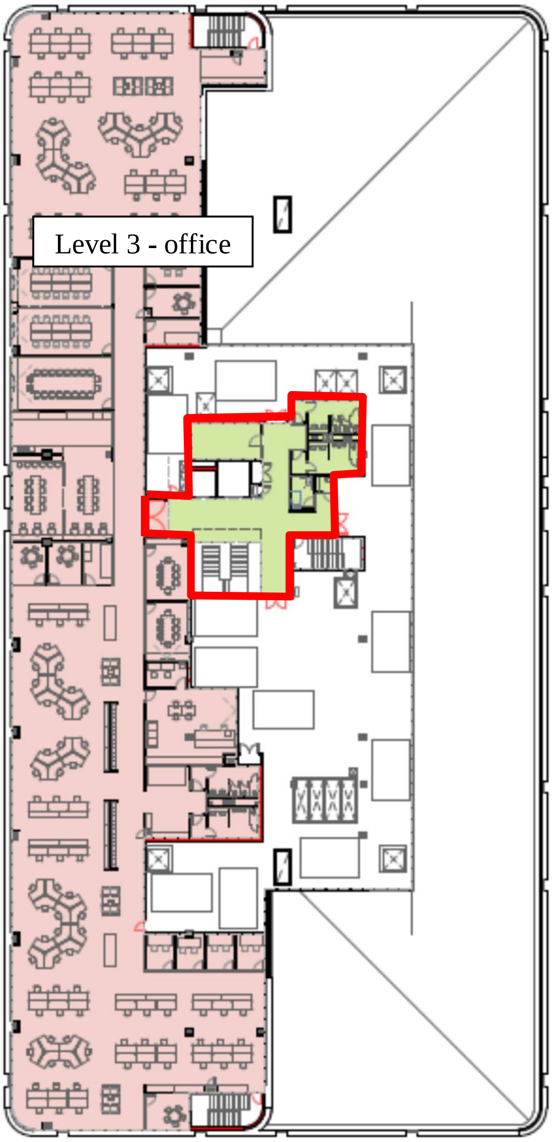

**Ground Level**



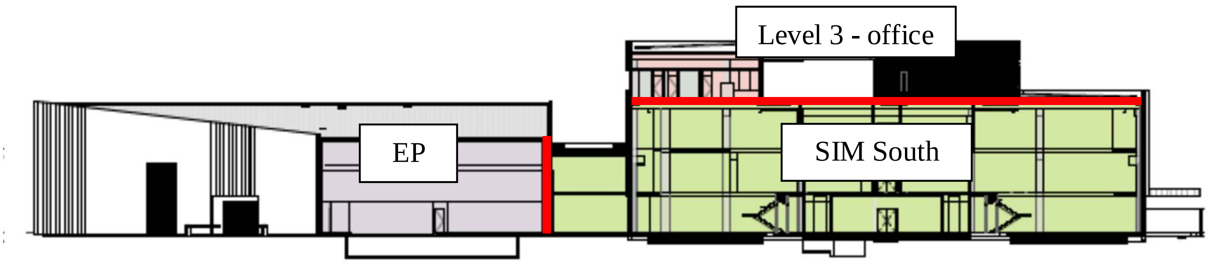

**Level 1**




**Level 2**




**Level 3**




**Section**

## References

[1] Australian Building Code Board, *International Fire Engineering Guidelines*, Edition 2005
[2] National Fire Protection Association, *SFPE Handbook of Fire Protection Engineering*, Fourth Edition, 2008
[3] AFAC (1997), Australasian Fire Authorities Council, *Fire Brigade Intervention Model*, Version 2.1
[4] McGratten, K., Hostikka, S., Floyd, J., *Fire Dynamics Simulator (Version 5), User's Guide*, NIST Special Publication 1019-5, National Institute of Standard and Technology, 2009.
[5] Forney, G., *Smokeview (Version 5)– A tool for visualizing Fire Dynamics Simulation Data, Volume 1:User's guide,* NIST Special Publication 1017-1, 2008
[6] National Fire Protection Association, Guide for Smoke and Heat Venting, NFPA 204, National Fire Protection Association, Quincy, MA, USA
[7] British Standards, *Application of fire safety engineering principles to the design of buildings – Part 1: Initiation and development of fire within the enclosure of origin (Sub-system 1)*, PD 7974-1:2003

# Qantas Staff Carpark at 297 King Street Mascot

## Fire Engineering Brief

Ref: 2019 – 001ND – FEB - 2
May 28, 2019
Rev 2

**FOR QANTAS AIRWAYS LIMITED**


(02) 8096 5235
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# Qantas Staff Carpark at 297 King Street Mascot

## Fire Engineering Brief

Ref: 2019 – 001ND - FEB
May 28, 2019
Rev 2

Prepared for: Qantas Airways Limited
Prepared by: XEL Consulting Pty Ltd
ABN: 30141218966



**Document Control**

| Revision | Date | Purpose | Author | |
|---|---|---|---|---|
| 1 | May 6, 2019 | For project team review | Xijuan Liu | |
| 2 | May 28, 2019 | For submission to FRNSW | Xijuan Liu | |
| | | | | |
| | | | | |

## Executive Summary

This report relates to a new standing alone multi- deck carpark building providing parking for Qantas staff members. The carpark is a part of the proposed Qantas Flight Group Training Centre (QGFTC) development at 297 King Street, Mascot NSW 2020, which will consist of a training / education (the QGFTC) building and the subject carpark building.

The proposed multi-deck car park will be adjacent the existing Qantas catering facility and tri-generation plant. The car park will contain thirteen (13) levels and provide 2059 spaces for Qantas staff. Vehicle access to the car park will be provided via King Street, Kent Road and from Qantas Drive via the existing catering bridge.

In the context of the BCA (Building Code of Australia) the carpark building is Class 7a, has a rise in storey of 13 and is required to be of Type A Construction. The effective height is 35.33m. A BCA report by Steve Watson & Partners identified deviations from the following *deemed-to-satisfy* provisions which may be subject to a Performance Solution to satisfy Performance Requirements of the BCA.

- D1.4 Exit travel distances - Travel distances to one of two or more exits exceeding 40m, up to 42m from the central area of every level.
- D1.5 Distance between alternative exits through the point of choice exceed 60m, up to 81m on every level.
- E1.3 Fire hydrant system is proposed to deviate from AS2419.1-2005 in lengths of internal hydrant hoses and the number of fire hydrants required to flow simultaneously.
- E1.4 Fire hose reels are proposed to be replaced with fire extinguishers to cover Class A risks in accordance with AS2444-2006 throughout the building.

XEL Consulting undertakes the assignment largely in accordance with the process and methods recommended in the International Fire Engineering Guidelines (IFEG). The fire engineering brief (FEB) process establishes the frame work of the assessment. This FEB report is utilized to facilitate stakeholder consultation so that stakeholder comments can be incorporated in the assessment and the preparation of the fire engineering report (FER). The FER is to be approved by the building certifier for the Performance Solution to be accepted. The main contents of this FEB report as amended to incorporate stakeholders' comments will be included in the FER.

The Trial Design incorporating Performance Solution is detailed in Section 6.

# 1 Introduction

## 1.1 Project Brief

This report relates to a new standing alone multi-level open deck carpark building providing parking for Qantas staff members. The carpark is a part of the proposed Qantas Flight Group Training Centre (QGFTC) development at 297 King Street, Mascot NSW 2020, which will consist of a training / education (the QGFTC) building and the subject carpark building.

The proposed multi-deck car park will be adjacent the existing Qantas catering facility and tri-generation plant. The car park is fourteen (14) levels and will provide 2025 spaces for Qantas staff. Vehicle access to the car park will be provided via King Street, Kent Road and from Qantas Drive via the existing catering bridge.

In the context of the BCA (Building Code of Australia) the carpark building is Class 7a, has a rise in storey of 13 and is required to be of Type A Construction. The effective height is 35.33m. A BCA report by Steve Watson & Partners identified deviations from the following *deemed-to-satisfy* (DtS) provisions which may be subject to a Performance Solution to satisfy Performance Requirements of the BCA.

The Performance Solution is to be developed and assessed in accordance with the process in the International Fire Engineering Guidelines (IFEG) and involves the following sub-system:

- *Sub-system E* Occupant Evacuation and Control
- *Sub-system F* Fire Services Intervention

## 1.2 Relevant stakeholders

The relevant project stakeholders involved in the fire engineering process are outlined in Table 1-1.

Table 1-1 Relevant project stakeholders

| **Name** | **Organization** | **Role** |
|---|---|---|
| Charlie Westgarth | Qantas | Owner representative |
| Michael Terrett | APP | Project manager |
| Darren Giffen<br>Andrew Jenner | Noxon Giffen Architecture | Architect |
| Ashwin Muralidharan | NDY | Fire services engineer |
| Darren Bofinger<br>Murray Macken<br>Matt Rowley | Fire & Rescue NSW | Concurrence authority |
| Jason Krzus | Steven Watson & Partners | Building certifier |
| Xijuan Liu | XEL Consulting Pty Ltd | Fire safety engineer |

## 2 Scope

### 2.1 Project Context

#### 2.1.1 Reference Codes & Guidelines

This assessment is prepared with reference to the following codes and guidelines:

a) Australian Building Codes Board, *National Construction code Series 2019, Volume One, Building Code of Australia Class 2 to Class 9 Buildings*, 2019 (BCA).

b) Australian Building Codes Board, *National Construction code Series 2016, Guide to Volume One, Building Code of Australia Class 2 to Class 9 Buildings*, 2019 (Guide to the BCA).

c) International Fire Engineering Guidelines, Australian Building Code Board, 2005.

#### 2.1.2 Information Considered

This report is prepared with consideration to the following information:

a) Architectural drawings prepared by Noxon Giffen Architecture as listed in Table 2-1;

b) BCA Assessment Report by Steve Waston & Partners, Report 2019/0208 R1.2 Carpark, 15 April 2019.

Table 2-1 Referenced drawings

| Drawing No. | Title | Issue | Date |
|---|---|---|---|
| A4.01.01 | Carpark-Plan -GA- Site | T1 | 2019.05.27 |
| A4.04.01 | Carpark-Plan -GA-L00 | T1 | 2019.05.27 |
| A4.04.11 | Carpark-Plan -GA-L01 | T1 | 2019.05.27 |
| A4.04.21 | Carpark-Plan -GA- Typical Floor | T1 | 2019.05.27 |
| A4.04.31 | Carpark-Plan -GA- -L04 Roof | T1 | 2019.05.27 |
| DA4.11 | Carpark-Roof Stage 02 | DA | 2019.04.11 |
| A4.09.01 | Carpark-Elevations | T1 | 2019.05.27 |
| A4.09.02 | Carpark-Elevations | T1 | 2019.05.27 |
| A4.09.11 | Carpark-Sections | T1 | 2019.05.27 |
| DA4.22 | Elevations – Stage 02 | DA | 2019.04.11 |
| DA4.23 | Elevations – Stage 02 | DA | 2019.04.11 |

### 2.2 Scope of the Fire Engineering Process

This fire engineering study is composed of developing a Building Solution incorporating Performance Solution and assessing it against relevant Performance Requirements of the BCA. The process of ire engineering consists of two stages, identified by the key deliverables as the Fire Engineering Brief (FEB) stage and the Fire Engineering Report (FER) Stage.

#### 2.2.1 FEB Scope

The FEB establishes the frame work of the assessment and develops trial design (s) to be assessed in the FER stage. Following the IFEG**Error! Bookmark not defined.** , the tasks of the FEB stage include

- Identify scope and objectives for the fire safety engineering assessment;
- Define fire safety acceptance criteria;
- Identify and agree on fire hazards;
- Establish and agree on fire and occupant evacuation scenarios;

- Establish system interaction and levels of redundancy;
- Establish method of assessment;
- Establish the trial design;
- Obtain agreement of the project Stakeholders on the FEB.

This FEB report is utilized to facilitate stakeholder consultation so that stakeholder comments can be considered in the assessment and the preparation of the FER.

### 2.2.2 FER Scope

The trial design will be analysed using input parameters and methods outlined in this report. The analysis results will be collated and evaluated against the Acceptance Criteria selected herein. The trial design may be adjusted as necessary to meet the Acceptance Criteria and thereby to satisfy the relevant Performance Requirements. The assessment will be documented in the FER, which is required to be submitted to the building certifier for the Performance Solution to be approved and implemented in construction. The main contents of this FEB report as amended as necessary to incorporate stakeholders' comments will be included in the FER.

# 3 Design Objectives

## 3.1 Fire Safety Objectives

The design objectives for fire safety are contained in the relevant BCA Performance Requirements in Sections C, D and E which may be summarized as follows:

- Occupant Life Safety – to safeguard people from illness or injury due to a fire in a building and whilst evacuating a building during a fire.
- Fire Brigade Intervention – to facilitate the activities of emergency services personnel.

## 3.2 Limitations of the Study and Reports

Following are limitations of the fire engineering assessment and reports.

- The reports do not apply to those situations where a person is involved, either accidentally or intentionally, with the fire ignition or early stages of development of a fire; building fire safety systems are not generally designed to protect such persons;
- The reports do not encompass situations that involve fire hazards outside the range normally encountered in buildings, such as storage of flammable liquids, processing of industrial chemicals or handling of explosive materials.
- Conventional building design can only provide limited protection against malicious attack. Large scale arson, large quantities of deliberately introduced accelerants, terrorism and multiple ignition sources has not been considered. These events can potentially overwhelm some fire safety systems.
- The goal of 'absolute' or '100%' safety is not attainable and there will always be a finite risk of injury, death or property damage. Fire and its consequent effects on people and property are both complex and variable. Thus, a fire safety system may not effectively cope with all possible scenarios. The intent of regulations related to health, safety and amenity in buildings and this report is to mitigate risks to a level acceptable to the community.
- The fire engineering reports do not address protection of property (other than adjoining property), business interruption or losses, personal or moral obligations of the owner/occupier, reputation, environmental impacts, broader community issues etc., unless specifically required by the client. For this building none of the above matters were not identified by the relevant stakeholders and are therefore not considered in this assessment.
- The study assesses the building as it will be when the proposed Performance Solution has been implemented; it does not address fire safety matters during construction/implementation of the Performance Solution.
- This report contains technical advice that may be used for obtaining building approval as necessary; it cannot replace any building approval/permit/certificate that may be required under relevant building regulation.

# 4 Principal building characteristics

## 4.1 Building usage

The proposed multi-deck car park will be located to the north-east of the flight training centre and adjacent the existing Qantas catering facility and tri-generation plant. The car park is 13 levels and will provide 2059 spaces for Qantas staff. Vehicle access to the car park will be provided via King Street, Kent Road and from Qantas Drive via the existing catering bridge.

## 4.2 BCA parameters

In the context of the BCA (Building Code of Australia) the carpark building is Class 7a, has a rise in storey of 13 and is required to be of Type A Construction. The effective height is 35.33m, higher than the 25m threshold to activate numerous *deemed-to-satisfy* provisions; however, the carpark will comply with the definition of an open-deck carpark which provides concessions in fire resistance levels and fire safety systems, as discussed in the following sections. Figure 4-1 shows the site and Ground Floor plan. The floor area of east level is approximately 4300m$^2$.

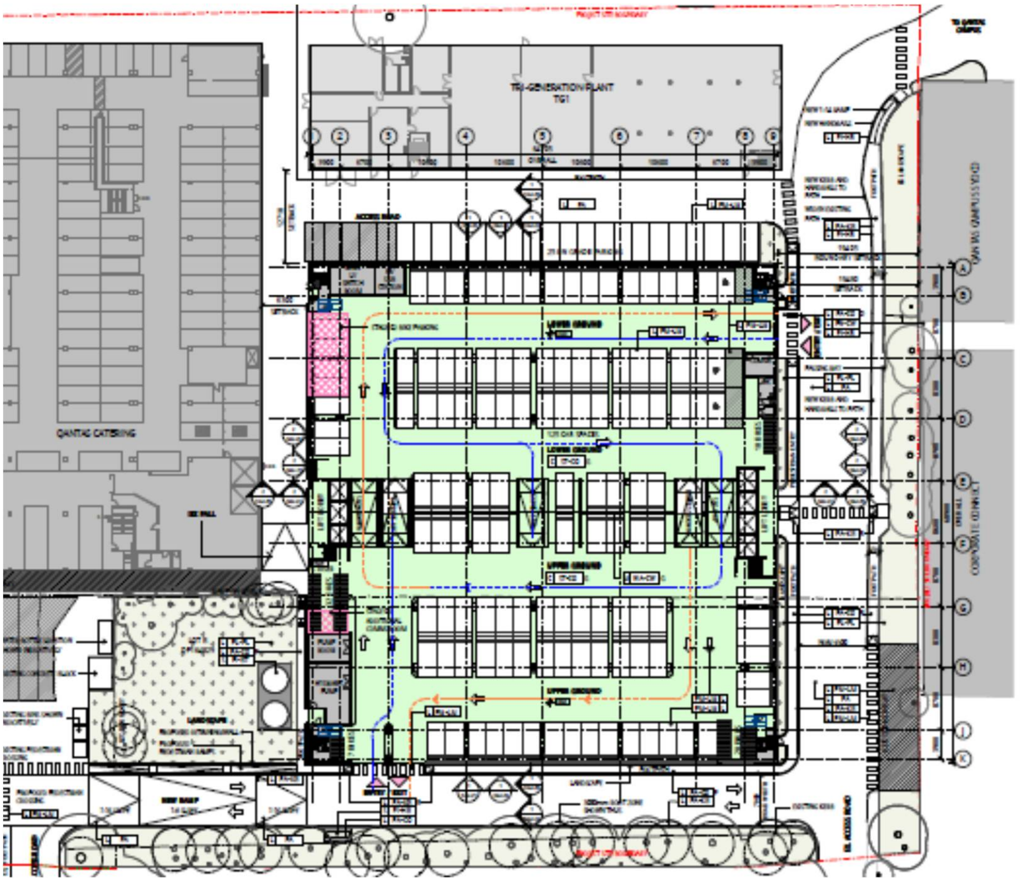


Figure 4-1 Ground floor plan

Key building characteristics in the context of the BCA that are based on to determine BCA *deemed-to-satisfy* provisions are summarized in Table 4-1 in accordance with the BCA report.

Table 4-1 Key determinants for BCA deemed-to-satisfy provisions

| | |
|---|---|
| Classification | Class 7a - carparking |
| Rise in storey | 13 |
| Type of Construction | Type A |
| Effective height | 35.33 m |

The car park building will be built in two stages. Stage 1 will be built up to Level 4, which will be the roof level for Stage 1. The east elevations of Stage 1 and Stage 2 are shown in Figure 4-2 and Figure 4-3, respectively.

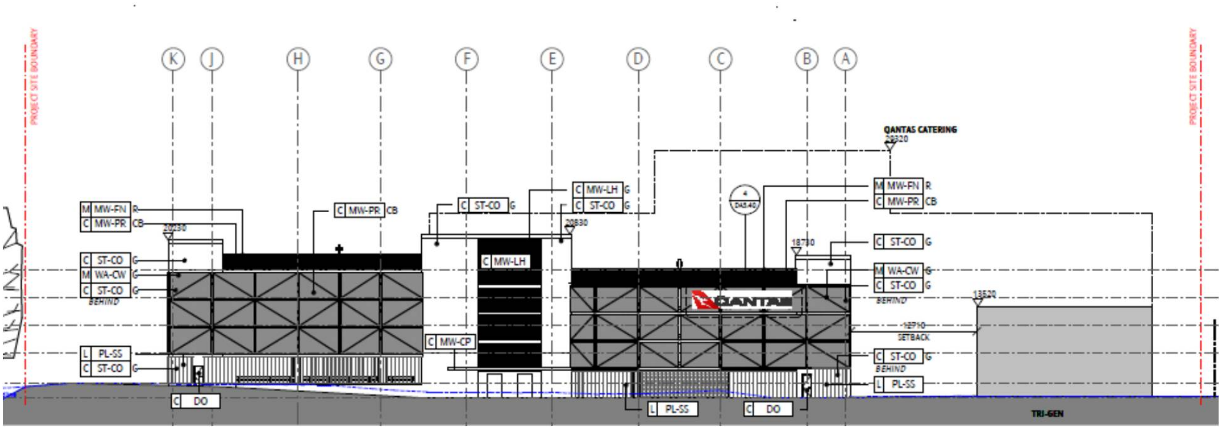


Figure 4-2 East elevation – Stage 1 / tender

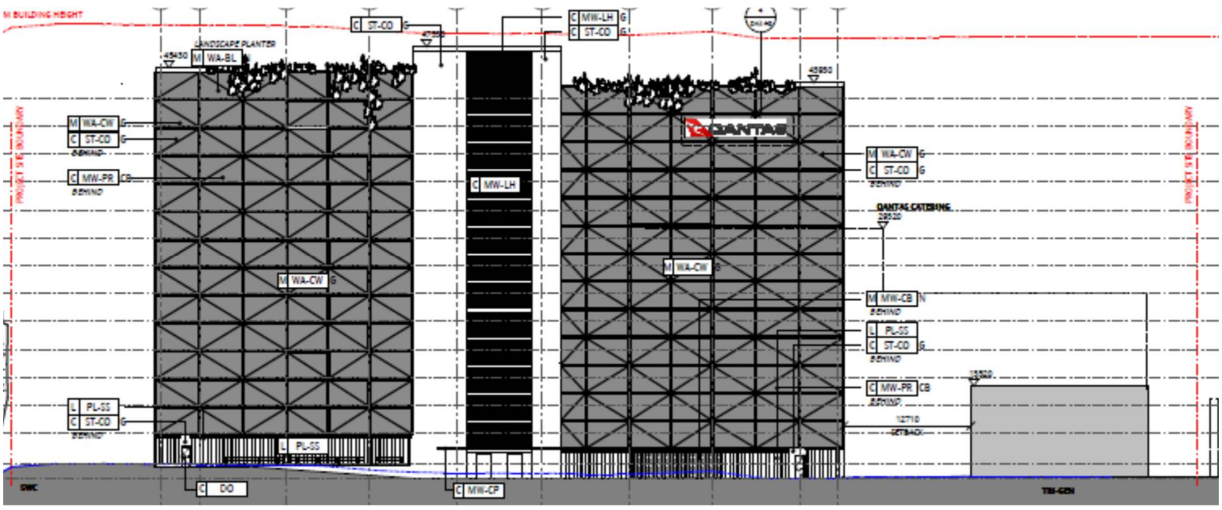


Figure 4-3 East elevation – Stage 2

# 5 Dominant occupant characteristics

## 5.1 Characteristics of key occupant groups

Occupants in the building under concern are Qantas staff members. Due to the usage of the building, all occupants are transient occupants who will be in the building for only a short time. Characteristics of the occupants are described in Table 5-1.

Table 5-1 – Occupant characteristics

| **Characteristic** | **Description** |
|---|---|
| Distribution – Age, Gender, Location | Staff members occupying the carpark are considered to be representative of the general workforce population and contain few elderly and no children. Staff members are expected to have normal physical and mental attributes. Occupants may be on any level, randomly distributed from parking spaces to lift lobby. Some occupants may be in moving vehicles. |
| State of Awareness | Due to the use of the building occupants are expected to be awake and alert. |
| Familiarity - egress routes, group roles, training | Staff members using the building will be mostly regular users. Occupants would be familiar with the locations of the lifts; however, they may not be very familiar with the egress routes to the fire stairs. Due to use of the building and no permanent occupants, it is not viable to have an emergency procedure that assigns roles in emergency for organized evacuation; however training may be provided to all staff likely to use the carpark building so that they are aware of the egress provisions and take appropriate actions. |
| Mobility | Most occupants will be mobile and able to evacuate independently. The proportion of occupants with disability is expected to be significantly lower than that of the general public population. |

# 6 Trial Design

The Trial Design comprises the proposed building design together with fire safety systems. Any aspects of the design not explicitly described under the Performance Solution are to comply with the *deemed-to-satisfy* provisions of the BCA and referenced Australian Standards.

## 6.1 Fire Resistance and Separation

Open deck carparks may comply with Table 3.9 of Specification C1.1 of the BCA, which requires 60-minute fire rating in general. As all boundaries are more than 3m from any fire source features, FRLs are not required for the external walls. The building is not required to be divided into fire compartments of limited floor area and volume as Clause C2.2 does not apply to an open deck carpark; the whole building is in one fire compartment.

Fire separation is to comply with relevant *deemed-to-satisfy* provisions of Part C2 of the BCA.

## 6.2 Egress Provisions

The carpark building will be provided with four fire isolated stairs, one at each corner. Travel distances from some central areas to the nearest exit exceed the 40m limit under Clause D1.4, up to 42m. Travel distances between alternative exit via the point of choice exceed the 60m under Clause D1.5, up to 81m. These travel distances will be subject to Performance Solution.

## 6.3 Fire Services Systems

Fire services systems are to comply with DtS provisions, and any additional measures required under the Performance Solution.

### 6.3.1 Firefighting equipment

***Fire hydrants***. The fire hydrant system will generally comply with AS2419.1-2005 except the following deviations.

- It is proposed that fire hydrant coverage to the central areas of each level will be provided via two lengths of hose (2×30m) from hydrants within the fire stairs in lieu of single hose from additional internal hydrants on the floor. Figure 6-1 shows the area that cannot be covered by a single length (30m) fire hydrant hose. This area is mainly around the car ramps.
- The flow capacity of the fire hydrant system will be based on three hydrants operating simultaneously. This deviates from the AS 2419.1-2005 requirements based on fire compartment size as the whole building is one fire compartment; however, the number of 3 hydrants exceed the 2 hydrants required to flow simultaneously when the floor area of the largest storey is between 500m$^2$ and 5000m$^2$ as per Table 2.2.2(D) of AS 2419.1-2017 which contains specific requirements for open deck carparks.

***Fire hose reels***. Fire hose reels are proposed to be replaced by portable fire extinguishers to cover Class A risks throughout the building under the Performance Solution.

***Portable fire extinguishers*** are to be provided to cover Class A risks throughout the building in the place of fire hose reels and other risks in accordance with BCA Clause E1.6 and AS2444-2006.

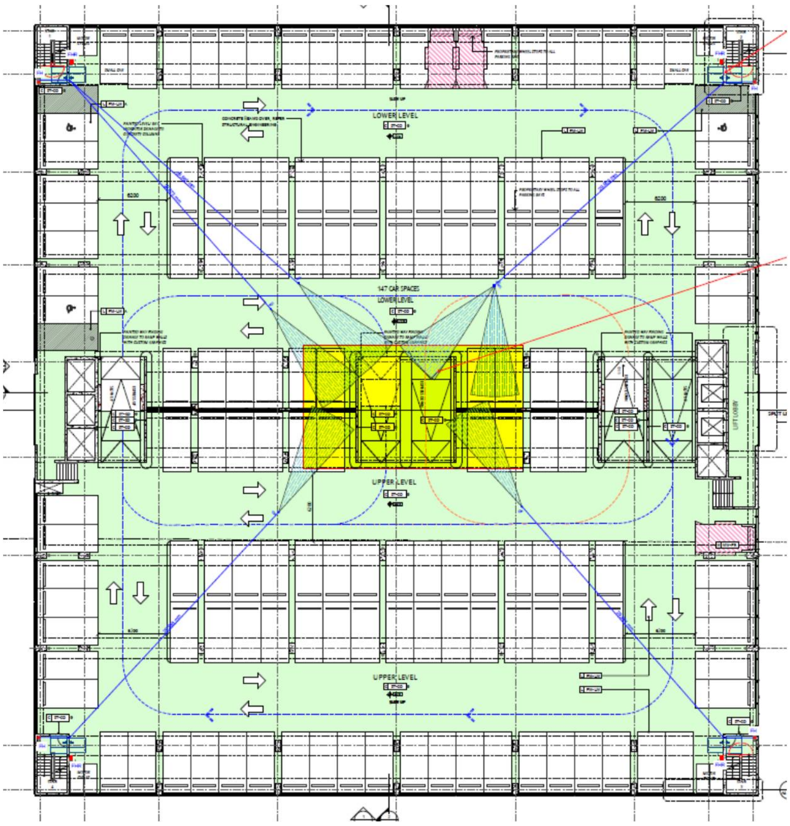

Figure 6-1 Single length fire hydrant coverage shortfall on typical level (highlighted area)

#### 6.3.2 Smoke hazard management

Smoke hazard management provisions under Part E2 do not apply to open deck carparks. However, heat detectors on extended (15m) spacing are proposed in order to activate the EWIS (Emergency warning and Intercom System) as discussed in Section 6.3.4.

#### 6.3.3 Emergency Lifts

As the effective height is over 25m, the building is to be installed with emergency lifts in accordance with BCA Clause E3.4.

#### 6.3.4 Visibility in an Emergency, Exit Signs and Warning Systems

***Emergency lighting and exit signs*** are to comply with Clause E4.4, E4.5, NSW E4.6, E4.8 and E4AS2293.1 - 2005.

***Emergency warning and Intercom System (EWIS)*** complying with AS1670.4 is required under Clause E4.9 due to the effective height exceeding 25m. As the building is not required to have an automatic fire detection or sprinkler system, it is proposed to install heat detectors at extended spacing on each level to activate the EWIS to provide early warning to occupants, especially those on levels other than that of the fire origin, as well as to provide early notification to FRNSW.

### 6.4 Commissioning and Maintenance Requirements

All fire safety systems maintenance and isolation should be in accordance with AS1851:2012.

## 6.5 Performance Solution

The deviations from BCA DtS provisions are detailed in Table 6-1, in the context of the relevant BCA DtS Clauses, Performance Solutions and the approach of assessment as per BCA Part A2.

Table 6-1– **Building Items Subject to Performance (Alternative) Solutions**

| Item No. | DtS Clause | Description | Proposed under Performance Solution | Performance Requirements | Verification Methods as per Clause A2.2 (2) |
|---|---|---|---|---|---|
| **1.** | **D1.4** | Exit travel distances | Travel distances to one of two or more exits exceeding 40m, up to 42m from the central area of every level. | DP4 | (b) (ii) other verification methods acceptable to the certifying authority |
| **2.** | **D1.5** | Distance between alternative exits | Travel distances between two alternative exits through the point of choice exceed 60m, up to 81m on every level. | DP4 | |
| **3.** | **E1.3** | Fire hydrant system | • Two lengths of hose (2×30m) to provide full coverage from hydrants within the fire stairs in lieu of single hose and additional internal hydrants on the floor; and<br>• The number of fire hydrants required to flow simultaneously will be 3, supported by AS2419.1-2017 which has more specific stipulation for open deck carparks. | EP1.3 | (b) (ii) other verification methods acceptable to the certifying authority; and<br>(d) comparison with the *deemed-to-satisfy* provisions |
| **4.** | **E1.4** | Fire hose reels | Fire hose reels are proposed to be replaced by portable fire extinguishers to cover Class A risks throughout the building. | EP1.1, EP1.2 | (d) comparison with the *deemed-to-satisfy* provisions |
| **5.** | | | | | |

# 7 Approaches and methods of analysis

## 7.1 Approach of analysis as per IFEG

The evaluation will involve the following sub-systems as per IFEG Part 1:

- *Sub-system E* Occupant Evacuation and Control
- *Sub-system F* Fire Services Intervention

The approach of analysis will be:

1. *absolute* and *comparative*. The impact of the extended travel distances will be analyzed, and the results will be matched using the agreed acceptance criteria against the acceptance criteria without comparison to a DtS benchmark design. The fire hydrant and fire hose reel deviations will be compared with DtS provisions.

2. *qualitative* and *quantitative* combined. Smoke spread modelling will be undertaken for assessing conditions for evacuation on the level of fire origin and the level above to obtain the Available Safe Evacuation Time (ASET). Egress analysis will be conducted to estimate time required for occupants to evacuate the afore mentioned levels, i.e. the Required Safe Evacuation Time (RSET). The quantitative analysis will enable comparison of ASET and RSET for assessing occupant safety.

   Qualitative assessment will be undertaken for the deviations in relation to fire hydrant and fire hose reels system.

3. *deterministic*. The analysis will not be based on probabilities of fire occurrence and system failure. A fire is assumed to have occurred and the consequences will be assessed.

## *7.2 Acceptance Criteria*

In accordance with the IFEG[1],

*When a fire engineering design is proposed, acceptance criteria must be developed in order to analyse the outcome of the design. The relationship between the acceptance criteria and the relevant Performance Requirements is often a matter of engineering judgement and therefore can vary between individual practitioners and from project to project. This variation can be minimised by the involvement of all stakeholders in the setting of the acceptance criteria that will also form an important part of the fire engineering brief.*

### *7.2.1 Tenability Criteria for Occupant Life Safety*

With reference to the SFPE handbook[2], the tenability criteria for occupant life safety to be applied are summarised in Table 7-1 and discussed further below.

Table 7-1 Occupant life safety criteria

| TENABILITY CRITERIA | DESCRIPTION |
|---|---|
| **Air/smoke temperature** | • Air/smoke temperature reaches 183°C (approximately equal to 2.5 kW/m$^2$) consistently across the entire fire enclosure at any height; or <br> • Significant pockets of air/smoke reaches 100°C in the vicinity of the egress path at a height of 2.1 m. |
| **Visibility** | • Substantial accumulation of stagnant smoke is formed below 2.1 m in the vicinity of the egress path such that visibility drops to be less than 10 m (i.e. an optical density of 0.1 m$^{-1}$) in path of travel, or less than 5m where occupants are queuing at exits. |

***Smoke layer height < 2.1m***

The risk of inhalation of potentially toxic combustion gases is minimised when the smoke layer is above head height during occupant evacuation. For the purposes of building design, a safe smoke layer height of 2.1 will be deemed to be acceptable. Once the smoke layer height is below 2.1m, the conditions become untenable when one or more of the following conditions is exceeded.

- Smoke temperature exceeds 100°C[13]. The tolerance time under medium humidity conditions is given by the following equation:

  $$t_1[min] = 2 \times 10^{31} \times T^{-16.963} + 4 \times 10^{8} \times T^{-3.7561}) \qquad (1)$$

  The above equation leads to a tenable time in excess of 10 minutes for an exposure temperature of 100°C.

- Smoke Optical Density

  The minimum acceptable visibility from a small enclosure is 5m (0.2 optical density/m), which, for irritant smoke, is that at which people behave as if in darkness. In large enclosures, occupants require much greater visibility to orient themselves and therefore a minimum visibility is required to be 10m (0.1 optical density/m)[13]. For the current analysis, a minimum visibility of 10m will be used for travelling in egress routes towards exits. Where occupants are queuing at an exit, a minimum visibility of 5m (0.2 optical density/m) will be used.

- Exposure to toxic gases of combustion

  It has been observed in several studies that Carbon Monoxide (CO) concentration is critical in determining the tenability in a smoky environment such as that obtained in a fire scenario. The International Fire Engineering Guidelines1 recommends the use of CO concentration as one of the acceptance criteria at 1400ppm (0.00168 kg/m$^3$). However, it has been observed that the mixture of asphyxiant gases (CO, $CO_2$, Low $O_2$ and HCN) is approximately additive and the tenability for total inhalation of asphyxiant gases can be related to optical density of smoke. It is recommended that the level of toxic products (asphyxiants and irritants), are unlikely to reach limiting levels for up to 30 min in situations where the smoke optical density does not exceed 0.1/m (or 10m visibility).

***Radiant Heat Impact on Occupants***

The maximum safe exposure level, for a duration greater than 5 min, is 2.4kW/m² [32]and therefore this radiation exposure level will be used as the acceptance criteria for safety during occupant evacuation. For flux greater than or equal to 2.5kW/m², the tolerance time for heat radiation is given by:

$$t_m = \frac{1.33}{q^{1.333}} \qquad (2)$$

Where:

$t_m$ = time (min) to incapacitation due to skin pain

q = the radiant heat flux (kW/m²).

Radiant heat flux may reach 2.5kW/m² when smoke temperature is 183°C; thus the radiant heat criterion is converted to temperature of 183°C for easier assessment as modelling results provide detailed information on temperatures.

### 7.2.2 Factors of safety

Factors of safety are quantified safety margins. The IFEG[1] states:

*The magnitude of the factors of safety adopted should be based on a consideration of:*

- *the extent of redundancy in the trial design*
- *the reliability of the various components of the fire safety system*
- *the analysis methods used*
- *the assumptions made for the analysis*
- *the results of an uncertainty analysis*
- *the acceptance criteria used*
- *the consequences of a fire.*

*As some of the above may not be quantified until the analysis has been completed, actual numerical values for the factors of safety may not be determined at the FEB stage. In such cases the FEB may give guidance on acceptable values and the fire engineer will need to justify the actual values used in the report.*

*Factors of safety should only be applied at the end of a calculation sequence, and not throughout the analysis steps because this could lead to over conservative outcomes.*

……

*For the purposes of sensitivity studies, less rigorous factors of safety may be appropriate in order to avoid overly conservative outcomes.*

For the ASET/RSET and ASIT/RSIT comparison approach, the factor of safety is defined as the ratio of the available time over the required time. The following factors of safety are selected for various fire scenarios and the subjects of the assessment.

Factor of safety for occupant evacuation,

- sprinkler controlled fire scenarios: ASET/RSET ≥ 1.5

- redundancy scenarios: ASET/RSET $\geq 1$

The FEB is to be distributed to stakeholders for agreement prior to proceeding with the FER. The above mentioned safety factors or other values agreed by stakeholders will be regarded as appropriate and adopted in the assessment.

### *7.2.3 Acceptance Criteria of the Performance Solution*

The acceptance criteria of the Performance Solution items in Table 6-1 are summarized as follows.

- PS #1&2 – extended travel distances: tenable conditions are maintained for occupant evacuation and fire brigade intervention, demonstrated by ASET/RSET and ASIT/RSIT comparison.
- PS #3 – fire extinguisher in lieu of FHRs: occupant undertaking first aid firefighting is not exposed to more hazardous conditions compared to the DtS benchmark design with full FHR coverage.
- PS#4 – fire hydrant system:
    - System design is acceptable to FRNSW.
    - Number of hydrants operating concurrently is not less than that of a DtS benchmark design.

## 7.3 Smoke Movement Model Used for Assessment

CFD modelling will be undertaken using NIST Fire Dynamics Simulator 6[3] ('FDS' hereafter). FDS is a computational fluid dynamics (CFD) model for fire spread and smoke movement. The software solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow with an emphasis on smoke and heat transport from fires.

FDS model requires that the room or building of interest be divided into small rectangular control volumes or computational cells. FDS computes the density, velocity, temperature, pressure and species concentration of the gas in each cell based on the conservation laws of mass, momentum, and energy to model the movement of fire gases.

The output of FDS simulations are presented and viewed in Smokeview[4], a software purposely developed to display FDS modelling results.

# 8 Design Fire Scenarios and Design Fires

## 8.1 Fire Hazards and Preventative and Protective Measures Available

Table 8-1 tabulates potential ignition sources and fire hazards of significance that are likely to be encountered in the building, and preventative and protective measures to mitigate the risk.

Table 8-1 – Potential ignition sources and fire hazards

| **Ignition Sources & Fire Hazards** | **Mitigation Measures** |
|---|---|
| *Ignition Sources*<br>Electrical fault<br>Motor vehicle defects / overheating<br>Arson*<br><br>*Fuel Load*<br>vehicles | *Building Management*<br>Regular maintenance of essential services<br><br>*Fire Safety Systems*<br>Fire hose reels<br>Fire hydrants<br>Heat detectors at extended spacing<br>Exit signage and emergency lighting<br>EWIS |

* *This report considers arson as a single ignition source. Major incidents of arson involving accelerants and/or multiple ignition sources are extreme events that are generally not addressed in fire engineering studies. The exclusive use of the building by Qantas staff means lower probability of arson compared to buildings permitting public access.*

## 8.2 Fire growth rates

Most fires that do not involve flammable liquids, gases or lightweight combustibles such as polymeric foams grow relatively slowly in the initial stage, or so-called incubation stage. For conservatism and due to uncertainties of fire ignition, the incubation stage is excluded in fire engineering assessment. As the fire increases in size, the rate of fire growth accelerates. This rate of fire growth is generally expressed in terms of an energy release rate. For design purposes, an exponential or power-law rate of energy release is often used. The most commonly used exponential relationship between time and heat release rate is the time-squared or t-squared fire, as referenced in the International Fire Engineering Guidelines[1]. In such a fire, the rate of heat release is given by the expression:

$$\dot{Q} = \dot{Q}_g\left(t/t_g\right)^2$$

where $\dot{Q}$ is the heat release rate, MW; $\dot{Q}_g$ is a constant, 1.055 MW; $t$ is time from ignition of the fire, $s$, $t_g$ is the growth time (seconds) for the fire to reach a heat output of 1.055 MW, $s$.

Full scale car fire tests have been undertaken by various research organizations to investigate car fire development and spread. A well-known series of tests were a part of the combined sponsored research project of several European countries[5]. The tests were conducted in well recognised fire research facilities in France (CTICM - Centre Technique Industriel de la Construction Metallique) and Finland (VTT). The subject of the European research project "development of design rules for steel structures subjected to natural fires in closed car parks" was to the study of the impact of car fires on steel structures of closed car parks.

A reference car fire curve was developed based on not only the abovementioned ten tests, but also other fire test results available in literature. Table 8-2 has been referenced from the report prepared from the car fire tests. Note this reference curve covers fire from cars of various sizes and fire propagation to the second car. Most car fires in the literature have lower heat release rate than this reference car fire at a given time. The reference fire is presented by time and heat release rate couples.

Table 8-2 Reference curve of heat release rate from car fire propagation[5]

| Time (min) | Heat Release Rate (MW) |
|---|---|
| 0 | 0 |
| 8 | 0 |
| 9 | 2.4 |
| 18 | 2.4 |
| 24 | 5.5 |
| 25 | 8.3 |
| 27 | 4.5 |
| 38 | 1 |
| 70 | 0 |

The heat release rate increases to 8.3MW within 17 minutes (note that the fire did not grow in the first 8 minutes) without sprinkler protection. If approximated by *t-squared* growth,

$$8.3\text{MW}=1054\text{kW} \bullet (17\times 60\text{s}/t_g)^2$$

where $t_g$, calculated to be 363s from the above equation, is the time taken for a *t-squared* fire to grow to 1054kW; therefore the reference car fire is closest to a medium *t-squared* fire.

## 8.3 Design fires

As the carpark is open deck and exempted from sprinkler protection, fires are not automatically controlled. The fire is assumed to continue growing.

Two fire locations are considered, on a typical level, say Level 3. The design fires are selected to represent the worst credible scenario for the features subject to Performance Solution.

Design Fire 1. A fire in the central area right on the lower split level next to a car ramp, for assessing potential of fire and smoke spread to multiple levels and impact on (i) concurrent occupant evacuation on the level of fire origin and the levels above and below; and (ii) non-compliant fire hydrant and fire hose reel coverage.

Design Fire 2. A fire at a corner of the split level, which may represent a worse case for smoke descending at far end of the fire due to smoke cooling under the slab.

The locations of the design fires are shown in Figure 8-1.

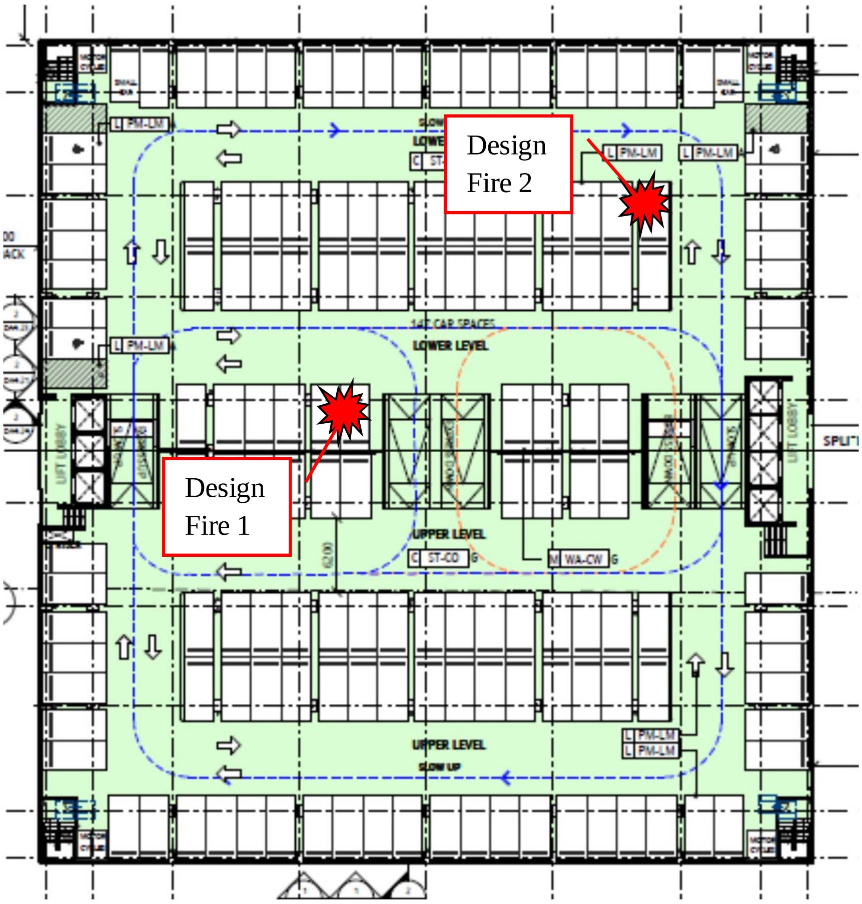


Figure 8-1 Locations of design fires

# 9 Conclusion

This Fire Engineering Brief (FEB) involves development and agreement of an appropriate methodology, format and trial concept design to enable preparation of the Fire Engineering Report (FER), in accordance with the International Fire Engineering Guidelines. In conjunction with consultation of relevant stakeholders, this document will form the basis for the fire safety analysis to be undertaken in the next stage to prepare the fire engineering report.

# References

[1] Australian Building Code Board, *International Fire Engineering Guidelines*, Edition 2005
[2] National Fire Protection Association, *SFPE Handbook of Fire Protection Engineering*, Fourth Edition, 2008
[3] McGratten, K., Hostikka, S., Floyd, J., *Fire Dynamics Simulator (Version 5), User's Guide*, NIST Special Publication 1019-5, National Institute of Standard and Technology, 2009.
[4] Forney, G., *Smokeview (Version 5)– A tool for visualizing Fire Dynamics Simulation Data, Volume 1:User's guide*, NIST Special Publication 1017-1, 2008
[5] Joyeux, D., "*Natural Fires in Closed Car Parks - Car Fire Tests*." CTICM Report No. INC-96/294d-DJ/NB, CTICM, Metz , France , 1997.