

Third Runway Project – APM Depot Fire Engineering Design

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More Than a Third Runway

The 3RS is a lot more than building an additional runway. The project includes seven core projects and facilities:



Third Runway Passenger Building and 57 parking positions

Floor area: **283,000 sq m**

Building a new passenger building with more than 280,000 square metres of floor area, a total of 57 new parking positions (frontal: 34, remote: 23) and an apron. When completed, there will be 173 passenger aircraft parking positions (frontal: 112, remote: 61) at HKIA.



New Automated People Mover system



Top speed: **80 km/h**



Building a 2,400-metre-long new APM system connecting T2 with the new passenger building. This new APM system takes 2.5 minutes to travel from T2 to the new passenger building. It can transport up to 10,800 passengers per hour.

New Baggage Handling System



Baggage transport speed: **7-10 m/sec**



Building a new baggage handling system linking T2 with the new passenger building.

Expansion of Terminal 2



Providing arrivals, departures and full-fledged passenger services

The expanded T2 and new passenger building will be able to serve 30 million additional passengers annually as stated in the HKIA Master Plan 2030.

New runway

← 3,800m

Building a 3,800-metre-long new runway and its supporting taxiway systems. The existing north runway will also be reconfigured.



Reclamation

Around **650** hectares of land
Using non-dredge methods, including deep cement mixing technique

Equivalent to 34 Victoria Parks, or 100 artificial islands for the New Wing of Hong Kong Convention and Exhibition Centre.

Comprehensive road network and transportation facilities



Presentation Overview

1. Project Background and Depot Overview
2. Building Information and Challenge for Code Compliant Design
3. Summary of Fire Safety Provisions
4. Non-code Compliant Items
5. Overview of Fire Engineering Approach
6. Fire Safety Management Plan

1 **Project Background and Depot Overview**

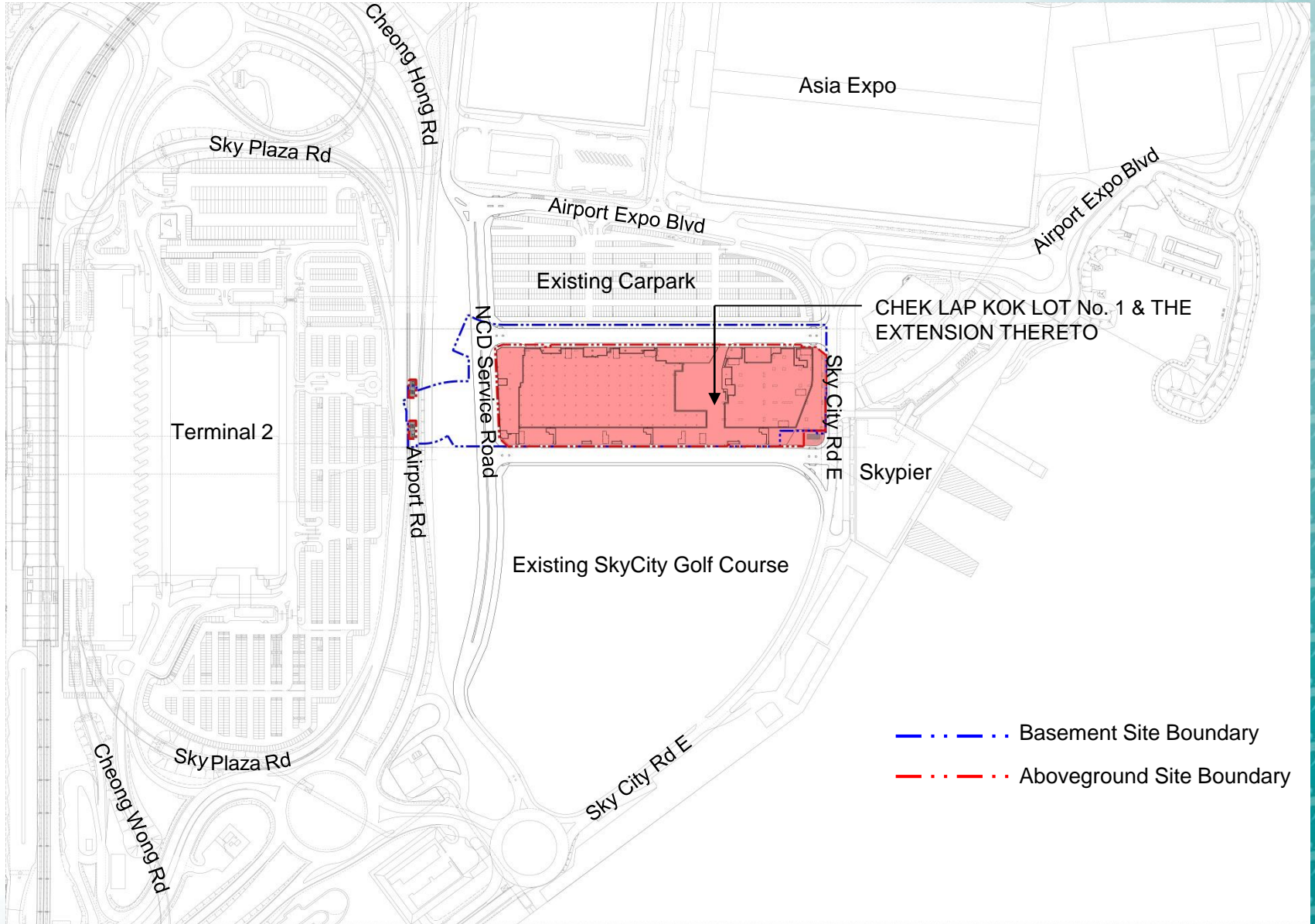
Key Issues related to New APM Depot

Depot design concept was presented to BD/FSD in Jan 2014

Following key issues on the Depot were discussed.

- Underground APM depot.
- Compartment size exceeding the Codes of Practice 10,500 sq.m,
- Common Emergency Vehicle Access at ground floor could adequately serve both APM depot below ground and commercial development above ground floor
- Underground APM depot together with the ground floor plant rooms, MoA and MoE staircases are to be treated as a separate building from the commercial development . Separate Occupation Permit for Depot.
- Hot works activity in the underground depot. Gas cylinders will not be stored in the underground APM depot as per the Dangerous Goods Ordinance.

Site Plan



Site Photo



2

Building Information & Challenge for Code Compliant Design

Building Information & Challenge for Code Compliant Design

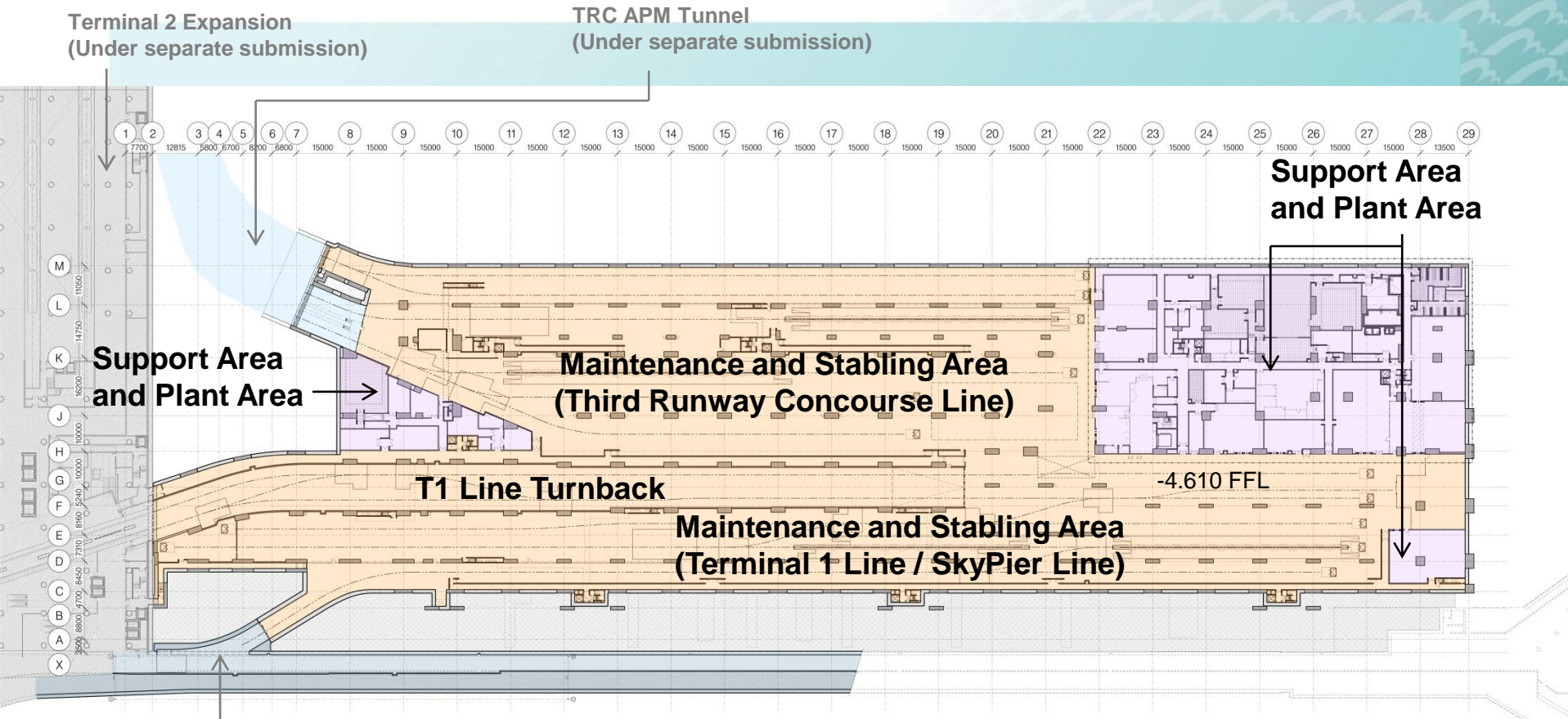
Building Information

- Unique Building Type - Underground Automated People Mover (APM) Depot
- Use Classification under FS Code 2011 – 6a
- Large Building Footprint - approximately 32,000 m² (370mL x 90mW)
- Occupant Capacity – 60 people per shift i.e. maximum 120 people
- Length of APM – 60 to 72m (6 cars)

Challenge for Code Compliant Design

- Difficult to subdivide the Depot due to Functional and Operational Need
- Difficult to locate Firefighting and Rescue Stairway due to Large and Deep Building Footprint

Level 1 Zoning Plan (Underground Level)

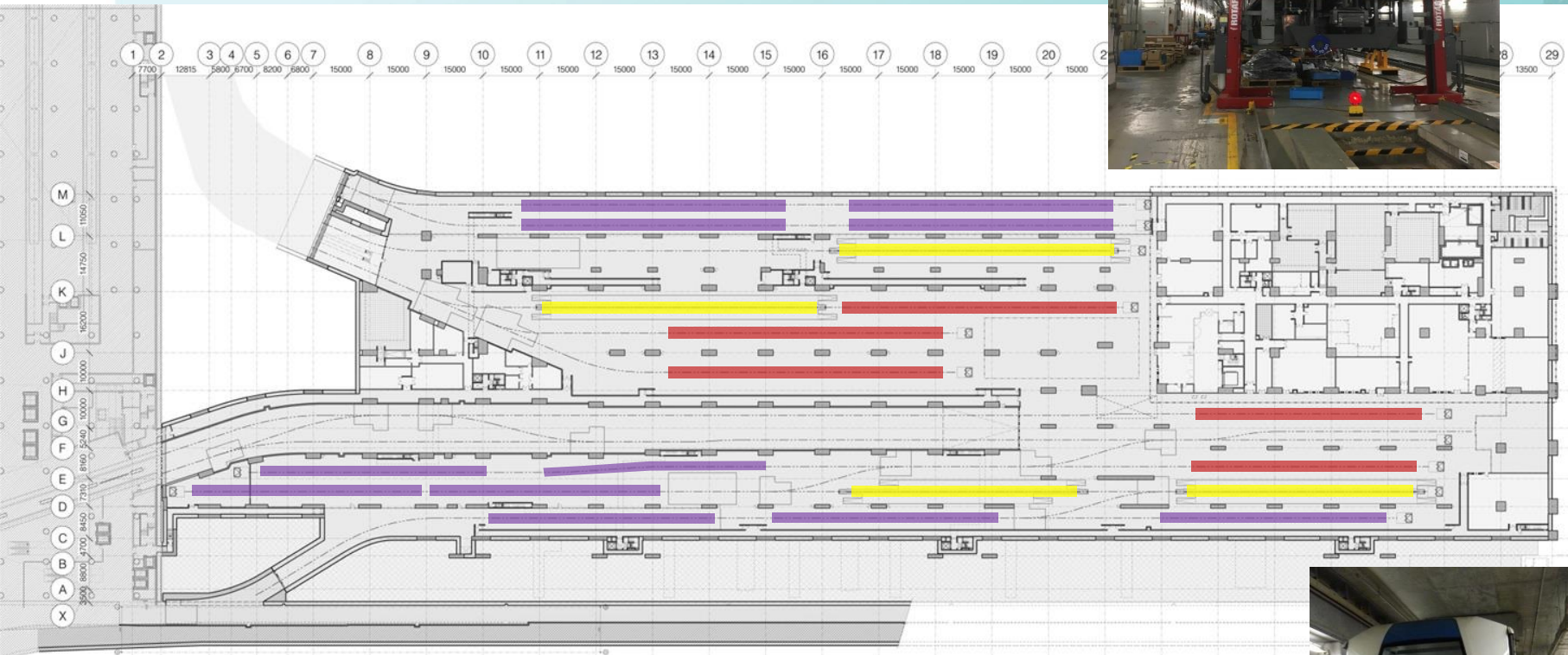




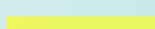
APM/BHS Tunnel between APM Interchange Station and SkyPier/ITT Station (A&A Plan and FER approved under separate submission)

Level 1 Functional Diagram of Maintenance & Stabling Area



Heavy Maintenance

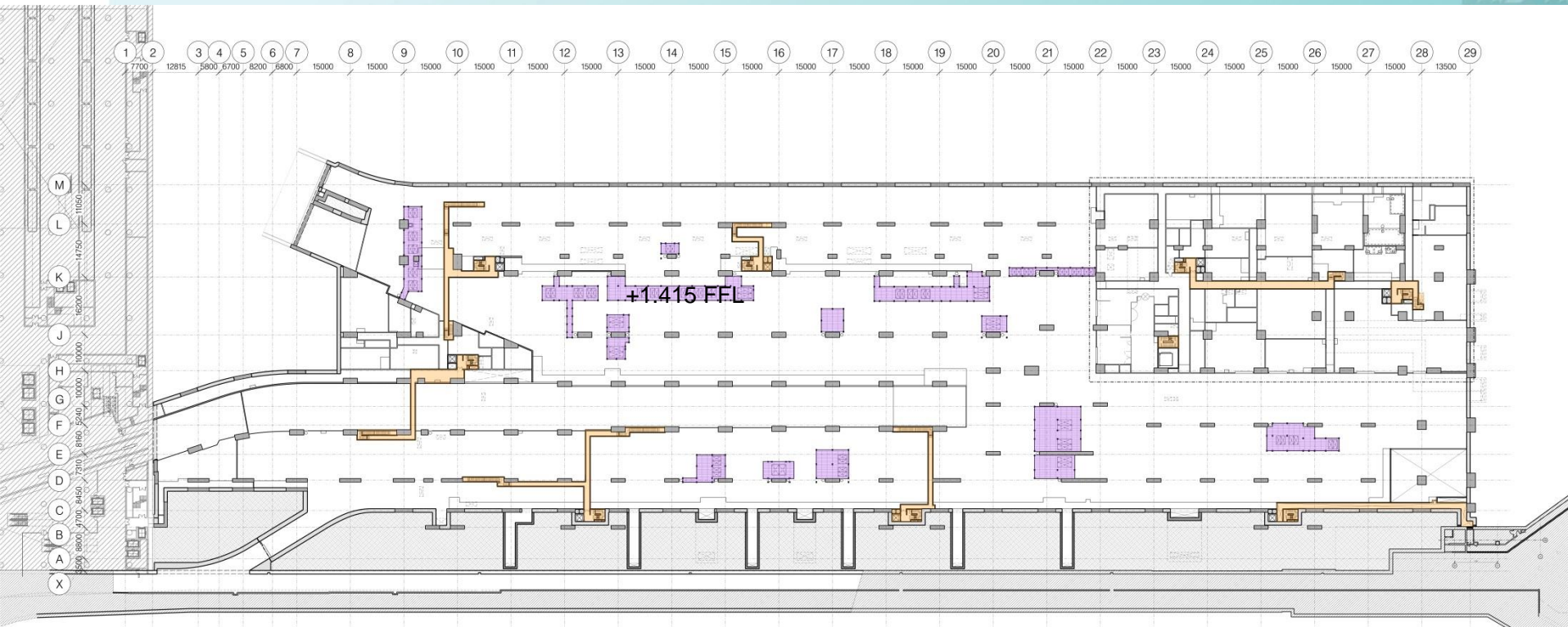


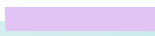
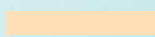
-  Stabling
-  Heavy Maintenance
-  Light Maintenance

Light Maintenance

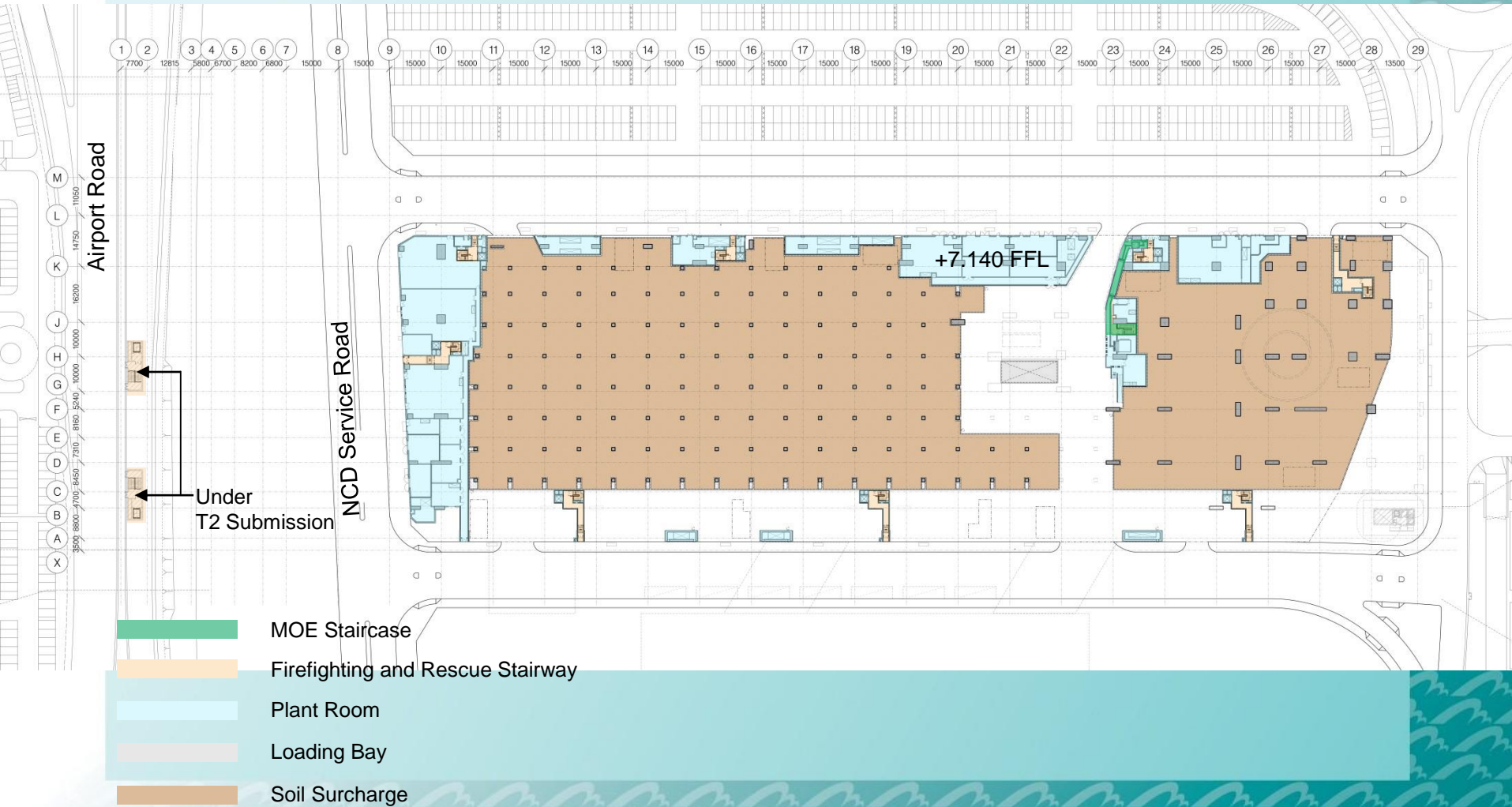


Level 2 Plan (Mezzanine Level)

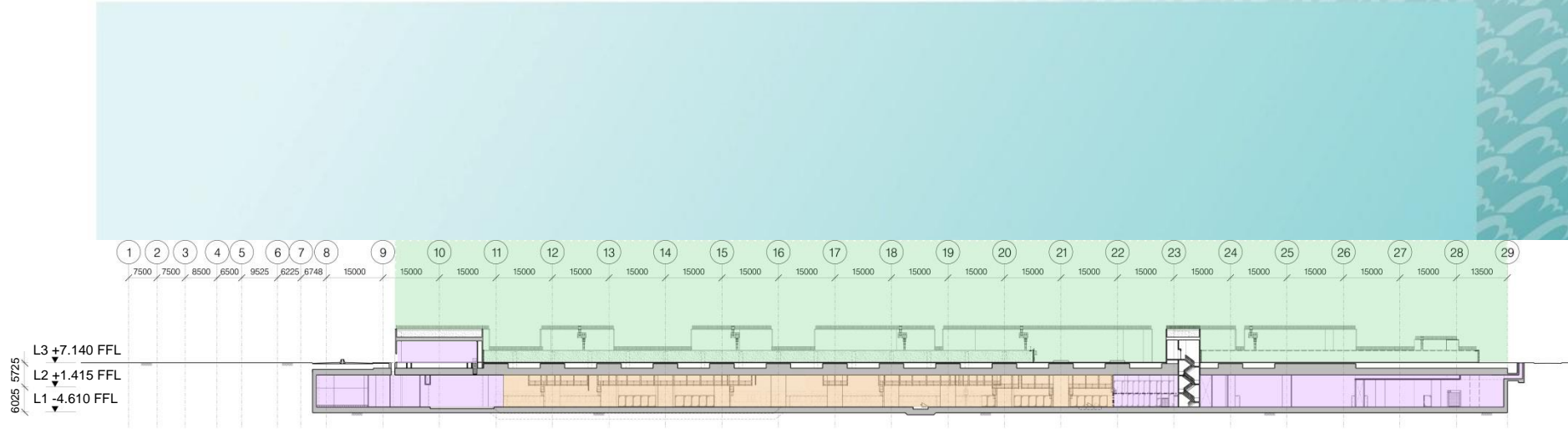





-  Maintenance Platform
-  High Level Protected Corridor

Level 3 Plan (Ground Level) – FRS and MOE Staircase



Longitudinal Section – Future NCD above

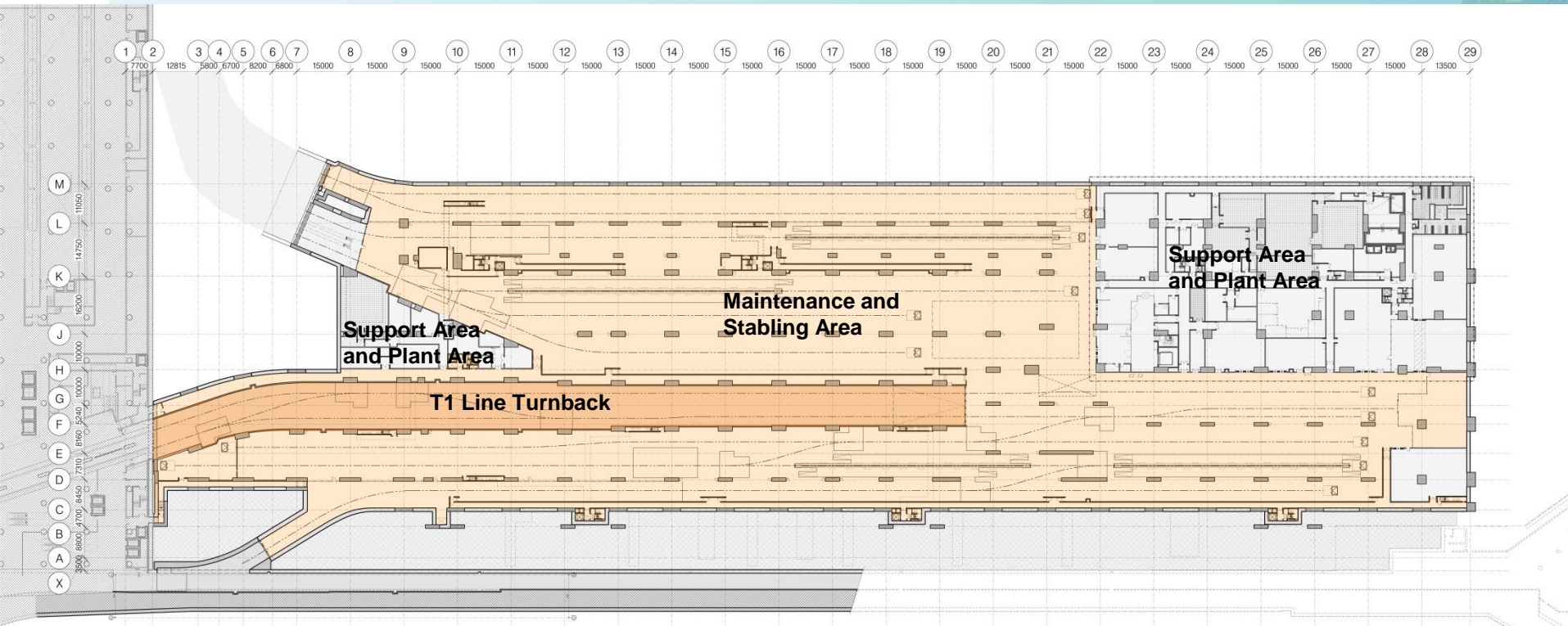


-  Envisaged Area to be handed over to NCD
-  Support Area and Plant Area
-  Maintenance and Stabling Area

3 **Summary of Fire Safety Provisions**

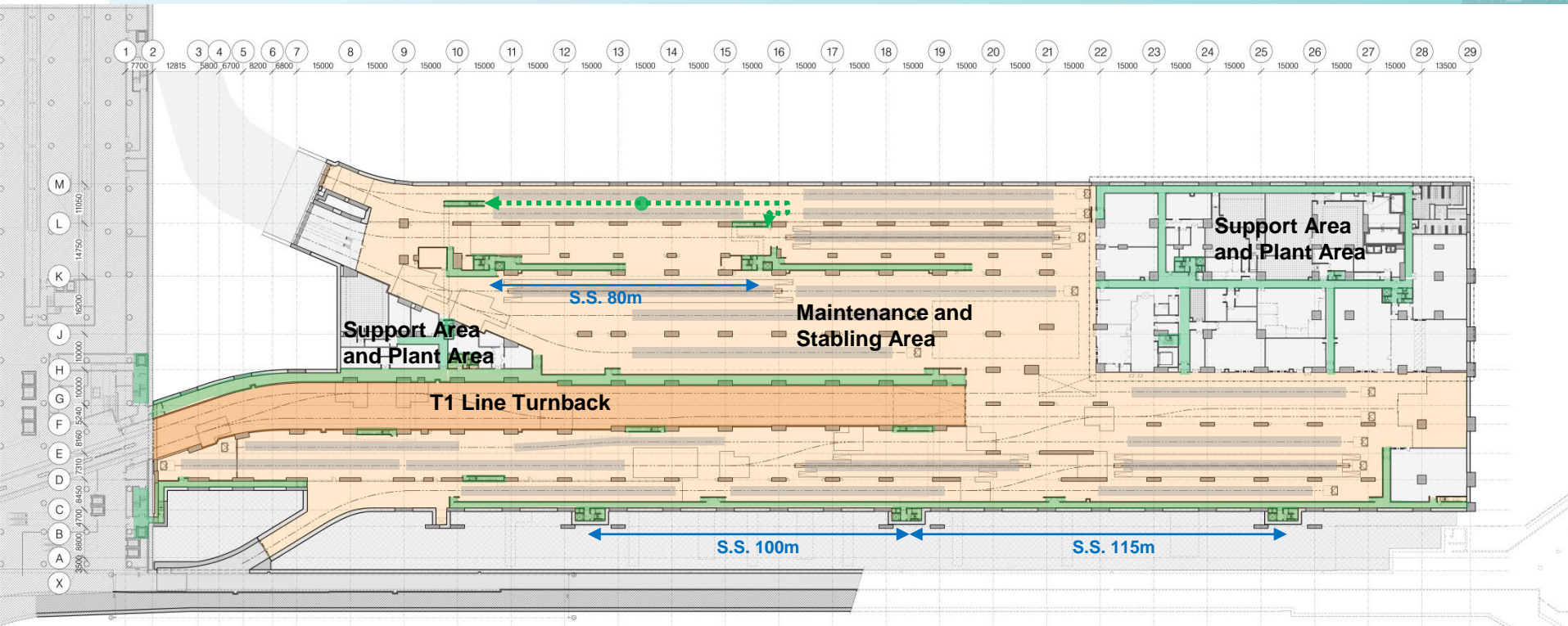
Fire Resisting Construction - Level 1 Plan

- Compartment Area at Support Area and Plant Area – Code Compliant
- Oversize Compartment at Maintenance and Stabling Area & T1 Line Turnback (> 10,500 m²) – Fire Engineering



Means of Escape - Level 1 Plan

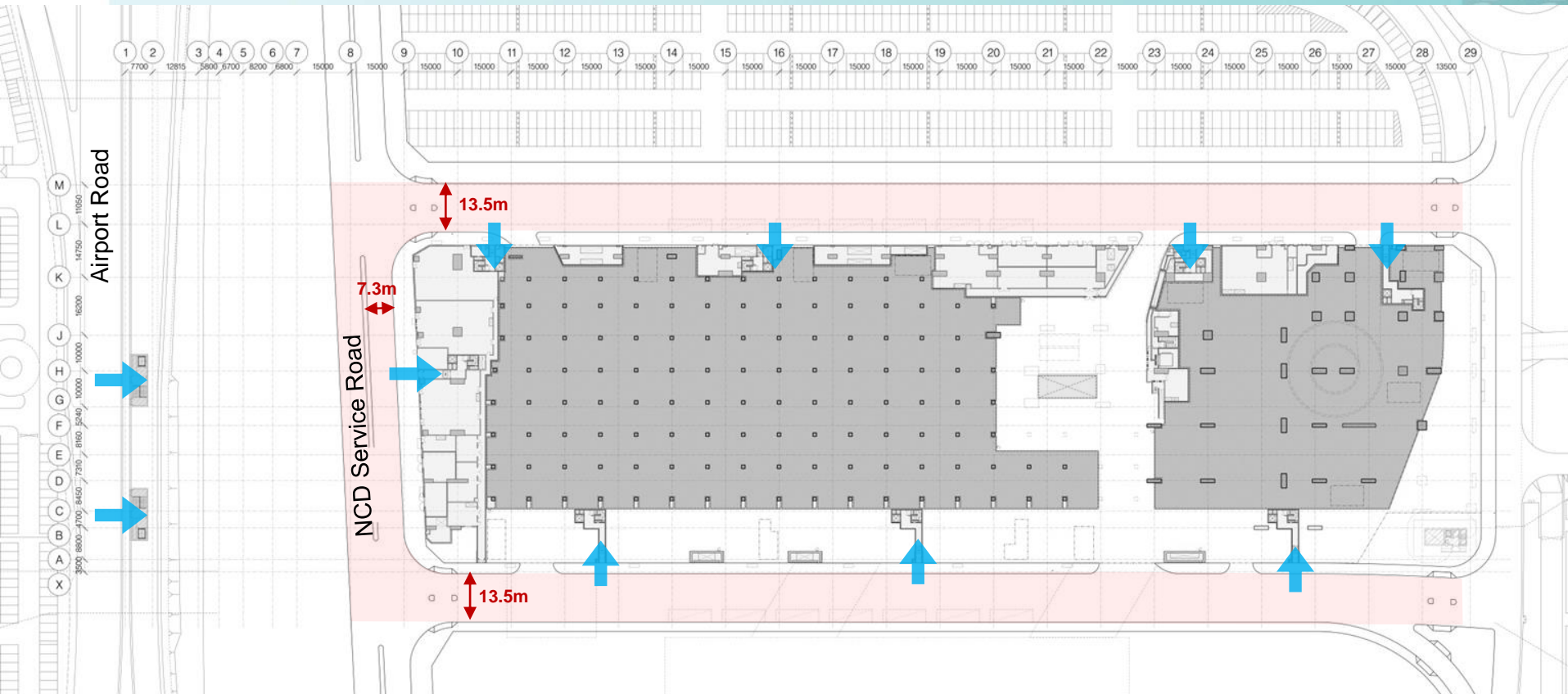
- MoE at Support Area and Plant Area (18m/36m) – Code Compliant
- Extended MoE travel distance at Maintenance and Stabling Area & T1 Line Turnback (25m/50m) – Fire Engineering
- Extended Staircase Separation at Maintenance and Stabling Area & T1 Line Turnback (over 48m) – Fire Engineering



Protected Exit

Means of Access - Level 3 Plan

- EVA – Code Compliant

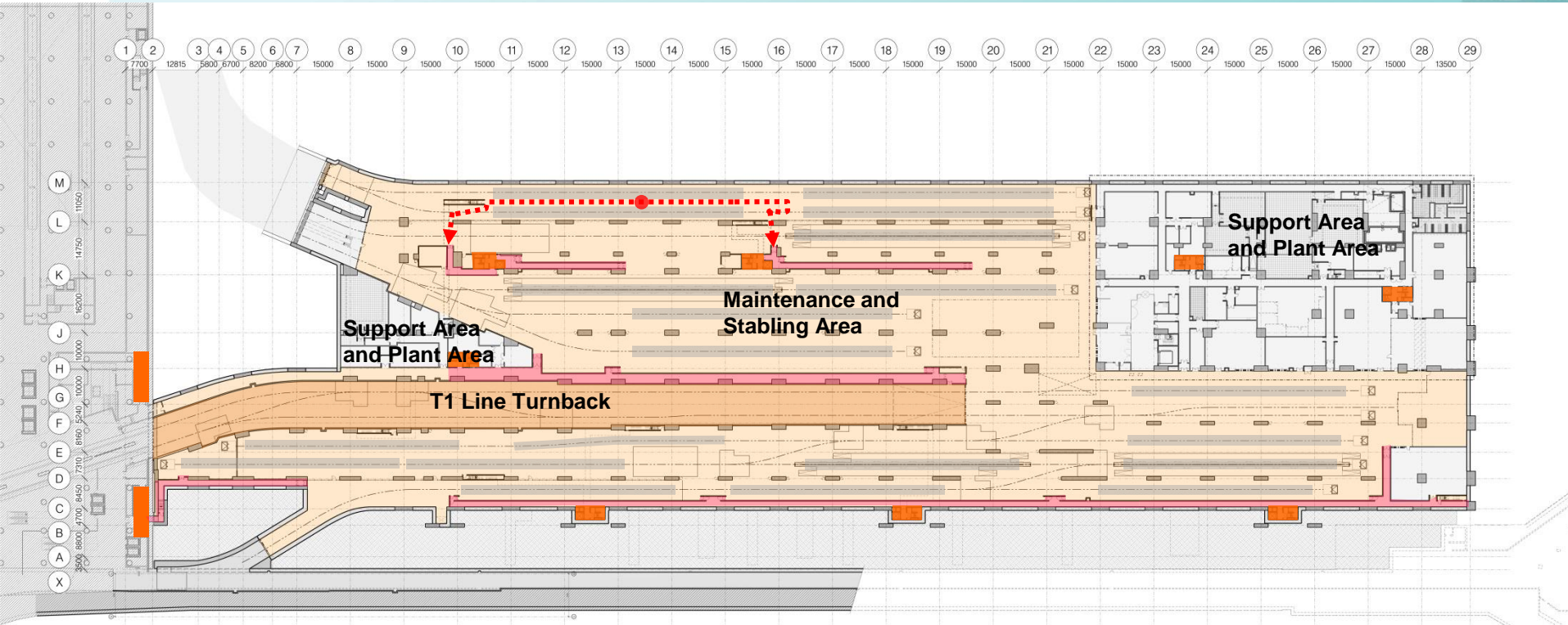


 Fire Service Access Point

 Emergency Vehicular Access

Means of Access (Firefighting and Rescue Stairway) - Level 1 Plan

- MoA travel distance at Support Area and Plant Area – Code Compliant
- Extended MoA travel distance at Maintenance and Stabling Area & T1 Line Turnback – Fire Engineering

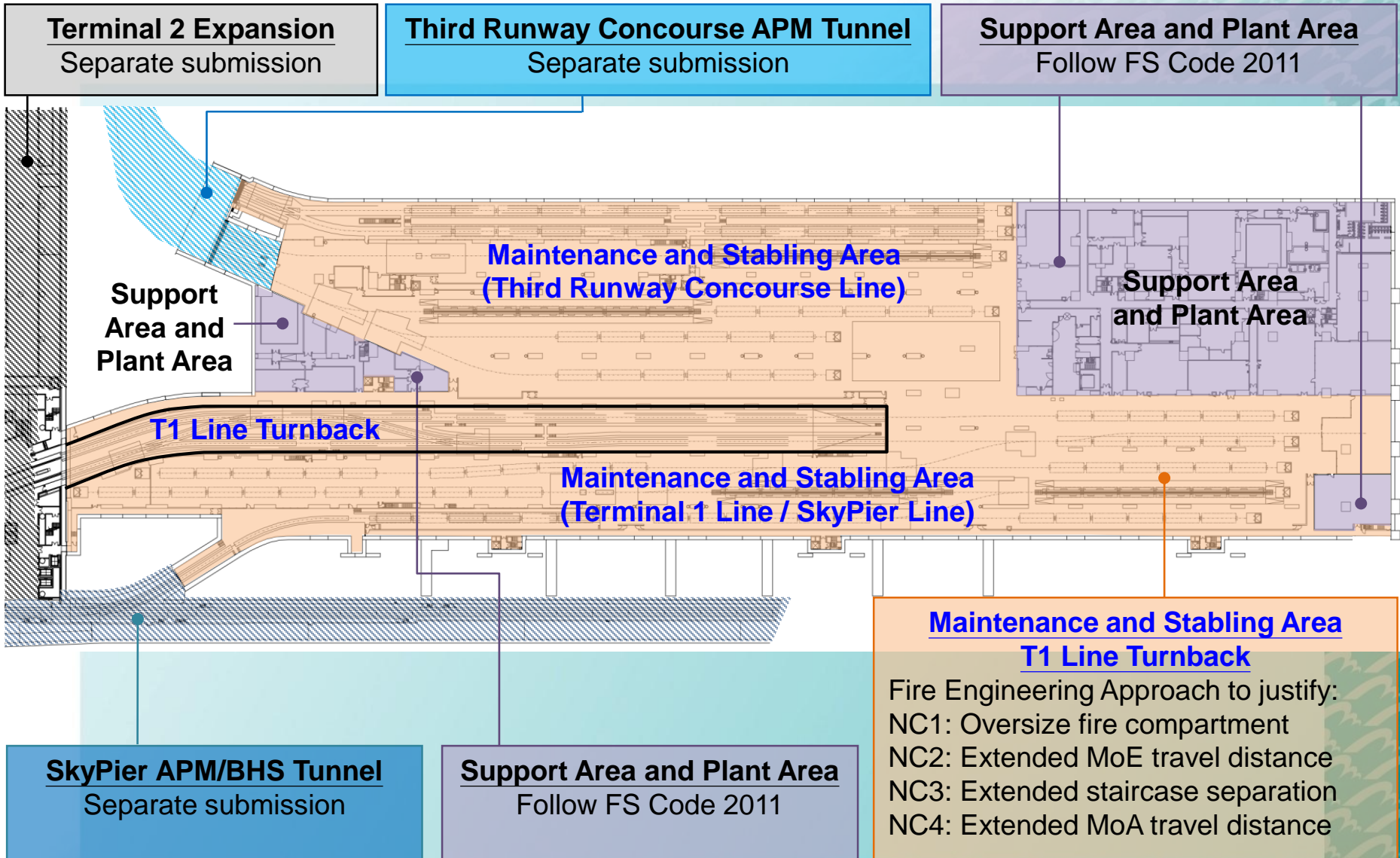


- Extended MoA Protected Corridor
- Firefighting and Rescue Stairway

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Non-code Compliant Items

Non-code Compliant Items



Non-code Compliant Items

NC1: Oversize fire compartment

Deviation from Deemed-to-Comply Provisions	Non-code Compliant Designs
<p>FS Code 2011 (Clause C3.1) Every building should be divided into fire compartments by fire barriers without exceeding the prescribed limit of fire compartment area (10,500m²).</p>	<ul style="list-style-type: none"><li data-bbox="857 429 1605 529">▪ Maintenance and Stabling Area: ~20,000m²<li data-bbox="857 601 1707 758">▪ T1 Line Turnback: ~2,700m² with no fire separation with adjoining APM tunnel

Non-code Compliant Items

NC1: Oversize fire compartment

Compartment 4

(Support Area and Plant Area)

- Area $\sim 760\text{m}^2$ ($< 10,500\text{m}^2$)

Compartment 1

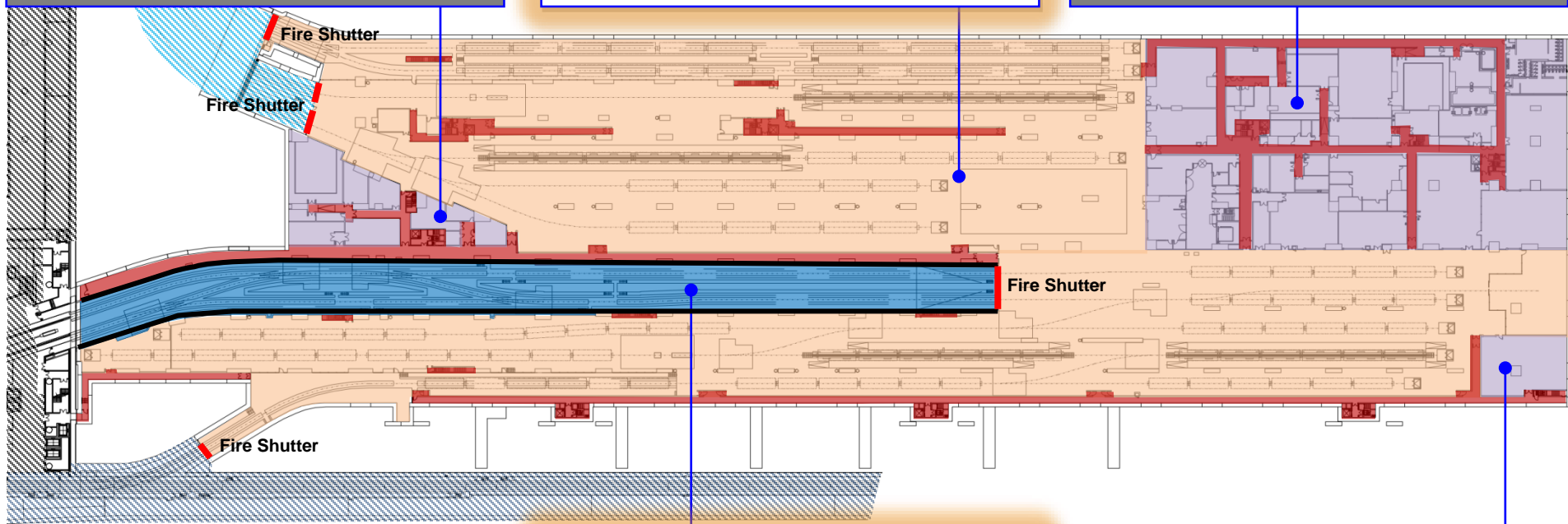
(Maintenance and Stabling Area)

- Area $\sim 20,000\text{m}^2$ ($> 10,500\text{m}^2$)
- Protected by engineered dynamic smoke extraction system

Compartment 2

(Support Area and Plant Area)

- Area $\sim 4,500\text{m}^2$ ($< 10,500\text{m}^2$)



Compartment 3

(T1 Line Turnback)

- $\sim 2,700\text{m}^2$ with no fire separation with adjoining APM tunnel
- Protected by push-pull longitudinal system

Compartment 5

(Support Area and Plant Area)

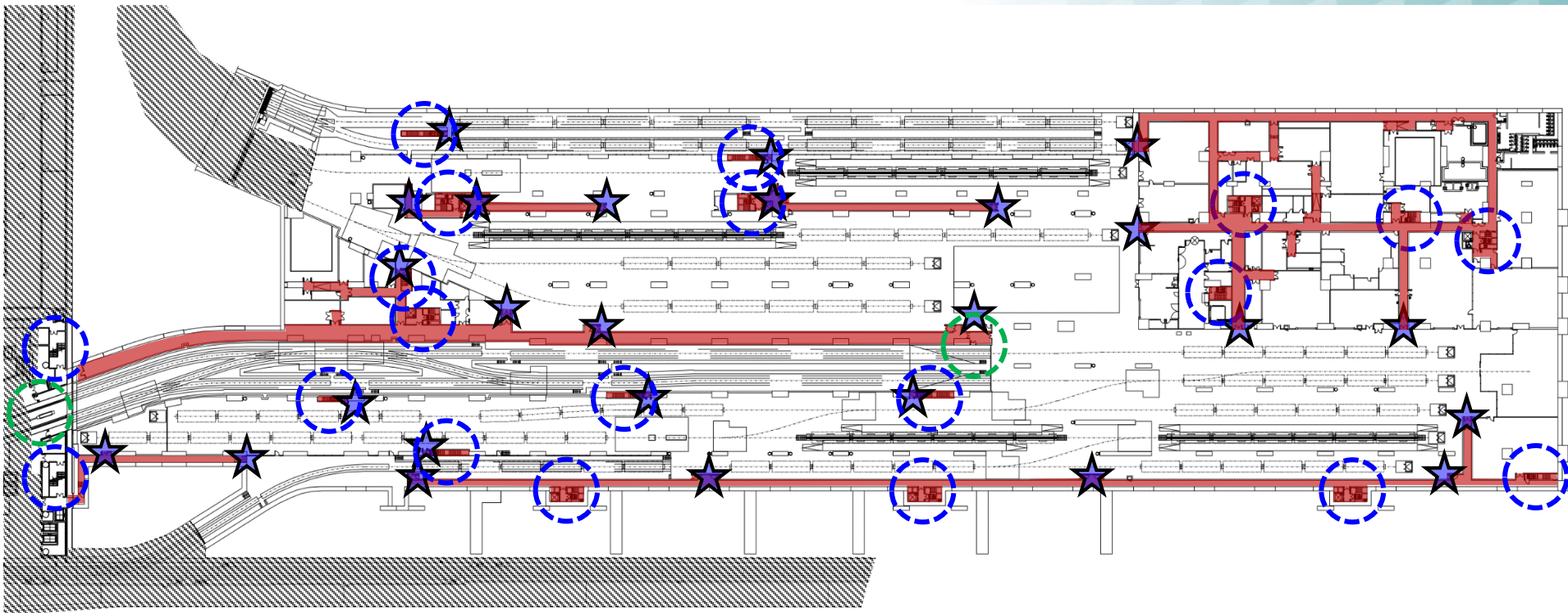
- Area $\sim 300\text{m}^2$ ($< 10,500\text{m}^2$)

Non-code Compliant Items





NC2: Extended travel distance for means of escape

Deviation from Deemed-to-Comply Provisions	Non-code Compliant Designs
<p>FS Code 2011 (Clause B11.2) The dead end travel distance is limited to 18m to a protected exit or to a point from which travel in different directions to 2 or more protected exits is available.</p> <p>FS Code 2011 (Clause B11.3) Travel distance to the nearest protected exit is limited to 36m when two or more protected exits are available.</p>	<ul style="list-style-type: none"><li data-bbox="852 425 1740 582">▪ Maintenance and Stabling Area: ≤50m to the nearest protected exit and ≤25m for dead end situation<li data-bbox="852 654 1644 811">▪ T1 Line Turnback: Exit points at both ends of T1 Line Turnback (260m apart)

Non-code Compliant Items



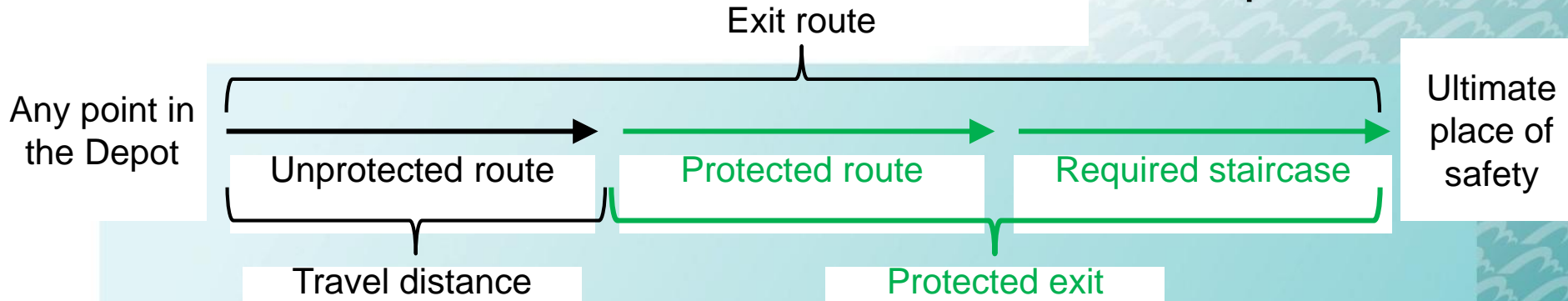
Key

-  Protected Corridor
-  Protected Staircase
-  Exit Point of T1 Line Turnback
-  Protected Exit of Maintenance and Stabling Area

Locations of Protected Exits for Maintenance and Stabling Area and T1 Line Turnback (Level 1)

Non-code Compliant Items

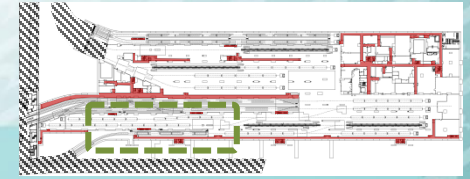
NC2: Extended travel distance for means of escape



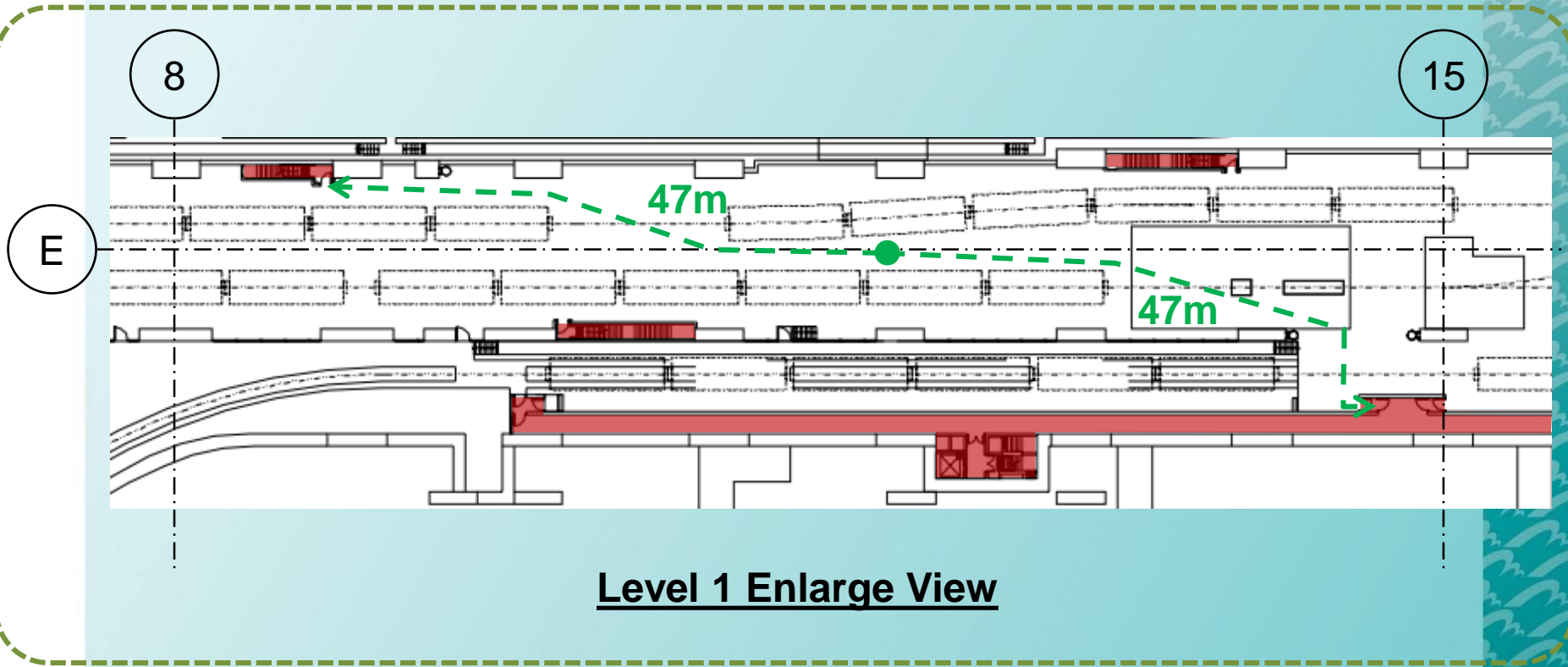
	Maximum Travel Distances	
	When two or more protected exits to an ultimate place of safety are available	For dead end situation
Maintenance and Stabling Area using fire engineering approach	50m	25m
T1 Line Turnback using fire engineering approach	Exit points at two ends (260m apart)	N/A
Support Area and Plant Area following prescriptive requirements	36m	18m

Non-code Compliant Items

NC2: Extended travel distance for means of escape



Level 1 Key Plan



Level 1 Enlarge View

MoE Travel Distance Illustration

Non-code Compliant Items

NC3: Extended staircase separation

Deviation from Deemed-to-Comply Provisions	Non-code Compliant Designs
<p>FS Code 2011 (Clause B11.3b) The horizontal distance measured on plan along the centreline of the exit route between a required staircase or a discharge point and any one of the other required staircases or discharge points should not exceed 48m.</p>	<p>Maximum separation between two staircases will be >48m.</p>

Non-code Compliant Items

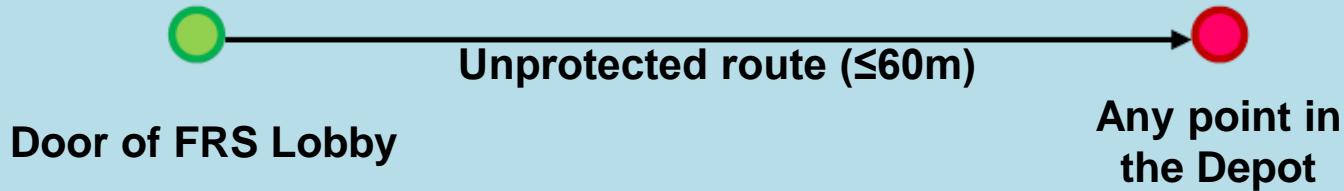
NC4: Extended travel distance for means of access for firefighting and rescue

Deviation from Deemed-to-Comply Provisions	Non-code Compliant Designs
<p>FS Code 2011 (Clause D15.6) No part of the floor served by a FRS should be more than 60m from the door of the lobby to the FRS measured along actual passages.</p>	<ul style="list-style-type: none">▪ Maintenance and Stabling Area: ≤60m from the door of the protected corridor▪ T1 Line Turnback: Firemen can access to the T1 Line Turnback from either end of T1 Line Turnback (260m apart)

Non-code Compliant Items

NC4: Extended travel distance for means of access for firefighting and rescue

Prescriptive Approach

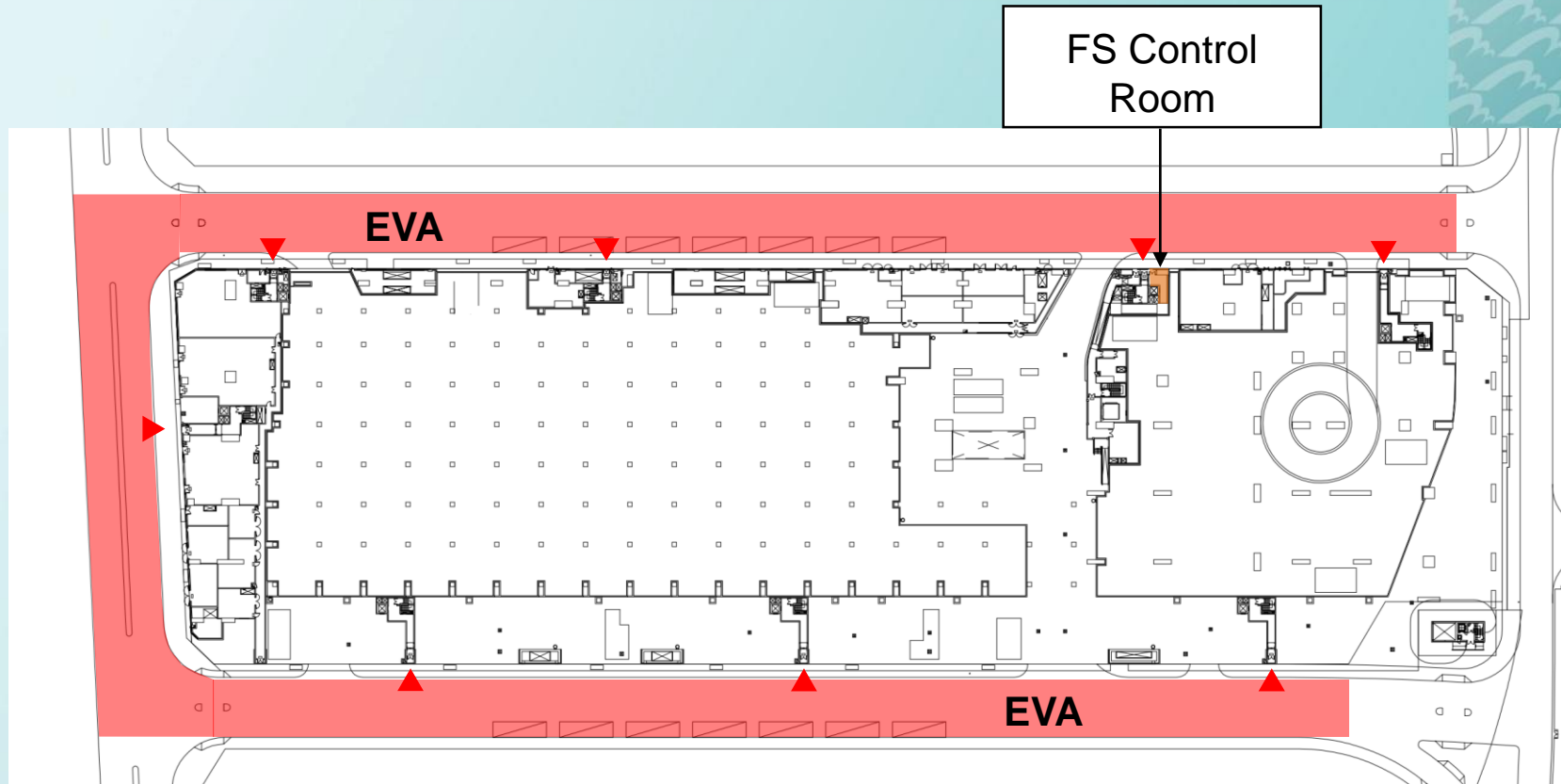


Fire Engineering Approach



Non-code Compliant Items

NC4: Extended travel distance for means of access for firefighting and rescue



Key

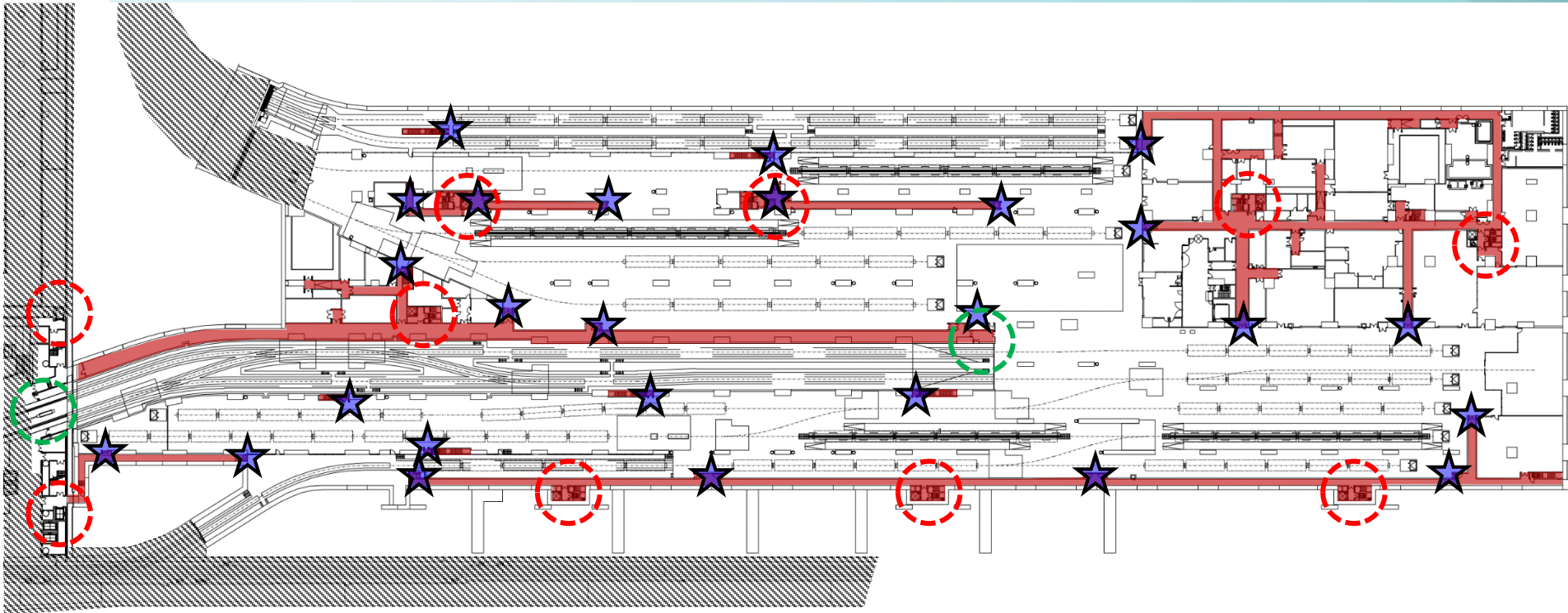
EVA

▲ Fire Service Access Point





FS Control Room

Non-code Compliant Items

NC4: Extended travel distance for means of access for firefighting and rescue



Key

-  Protected Corridor
-  Fireman's Lift
-  Exit Point of T1 Line Turnback
-  Protected Exit of Maintenance and Stabling Area

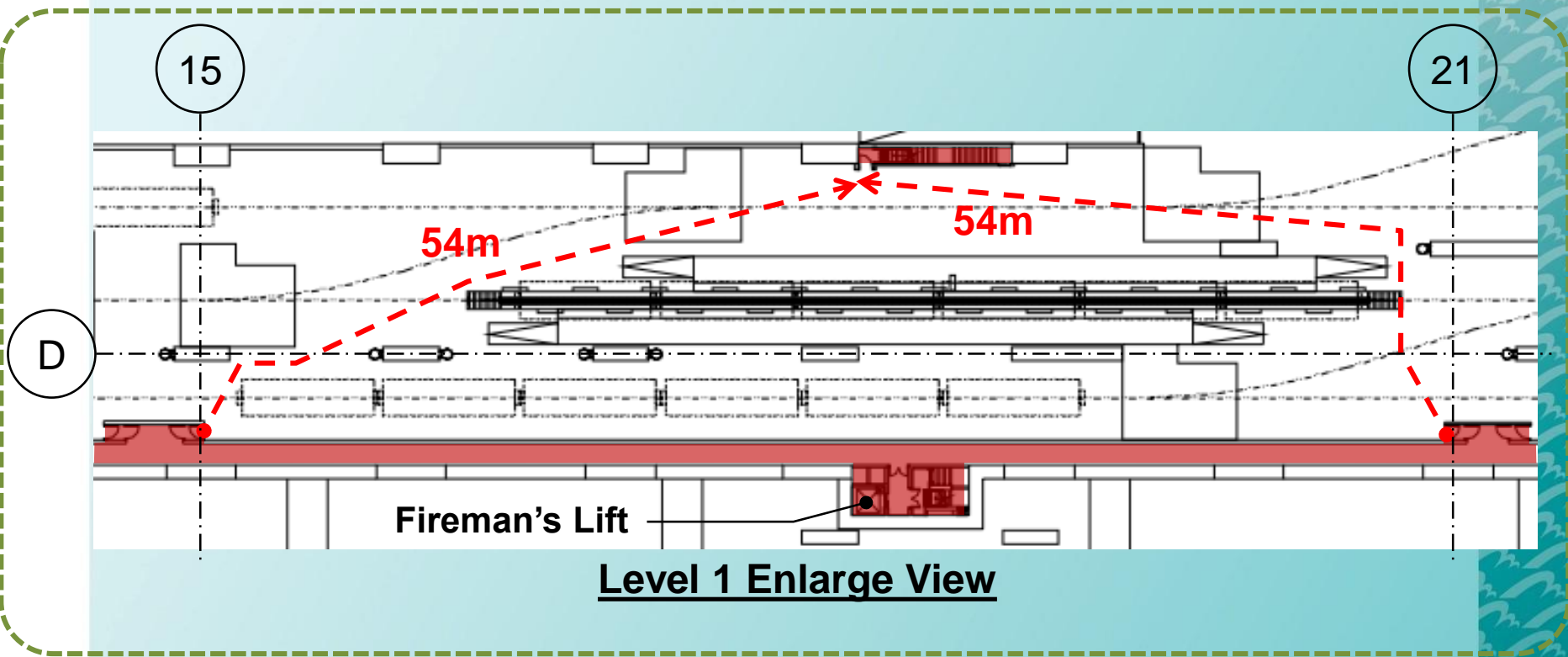
Locations of Protected Exits for Maintenance and Stabling Area (Level 1)

Non-code Compliant Items

NC4: Extended travel distance for means of access for firefighting and rescue



Level 1 Key Plan



Level 1 Enlarge View

MoA Travel Distance Illustration

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Overview of Fire Engineering Approach

Overview of Fire Engineering Approach

Key Objectives:

1. Protection of life of building occupants
2. Minimization of fire and smoke spread
3. Facilitation of firefighting and rescue

Overview of Fire Engineering Approach

ASET/RSET Analysis

1. Available Safe Egress Time (**ASET**) by Computational Fluid Dynamics (CFD) analysis using Fire Dynamics Simulator (**FDS**)
2. Required Safe Egress Time (**RSET**) by evacuation analysis using **STEPS**
3. $ASET > RSET$ with safety factor of ≥ 1.5

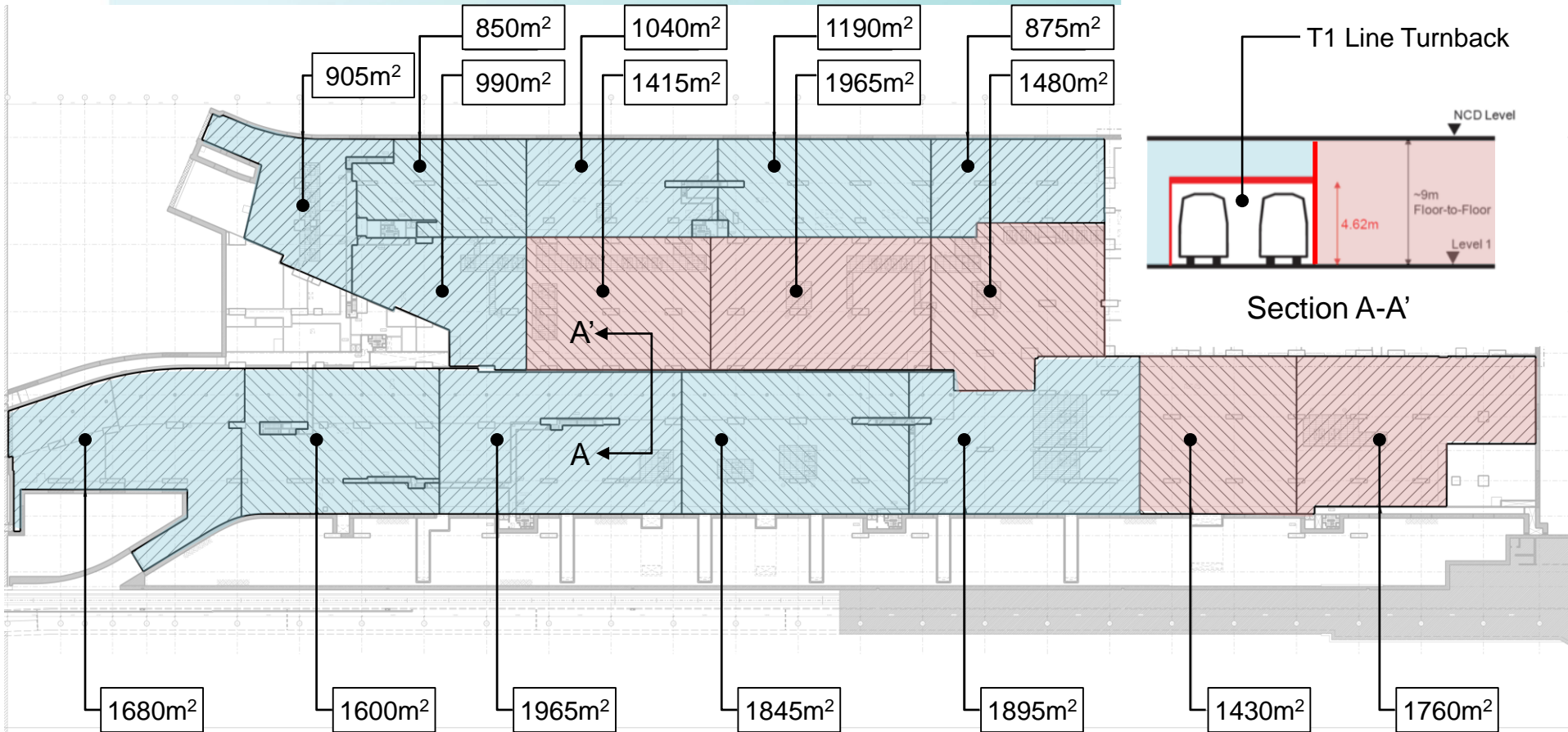
Overview of Fire Engineering Approach

Maintenance and Stabling Area

- Dynamic smoke extraction system
- Smoke zone area $\leq 2000\text{m}^2$
- Smoke zone length $\leq 60\text{m}$

Bottom level of smoke barriers = 5.76m AFFL
Smoke extraction rate = $119\text{m}^3/\text{s}$

Bottom level of smoke barriers = 4.25m AFFL
Smoke extraction rate = $77\text{m}^3/\text{s}$



Mechanical – Smoke Extraction System

Smoke Extraction System (Maintenance / Stabling Area)

- Subdivided into (16) smoke zones
- Area $\leq 2000\text{m}^2$ and Length $\leq 60\text{m}$
- Boundary fire scenario confined across TWO smoke zones only

	Smoke Clear Height	Smoke Extraction Rate (w/ 10% safety)
Light Maintenance/Stabling Area	4450 AFFL	77 m ³ /s
Heavy Maintenance Area	5960 AFFL	119 m ³ /s

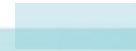


Overview of Fire Engineering Approach

CFD Simulation Scenarios



Bottom level of smoke barriers = 5.76m AFFL
Smoke extraction rate = 119m³/s



Bottom level of smoke barriers = 4.25m AFFL
Smoke extraction rate = 77m³/s

Scenario 3

- 10MW APM fire
- Three sides enclosed by walls

Scenario 1

- 10MW APM fire
- Three-side connections with other smoke zones

Scenario 2

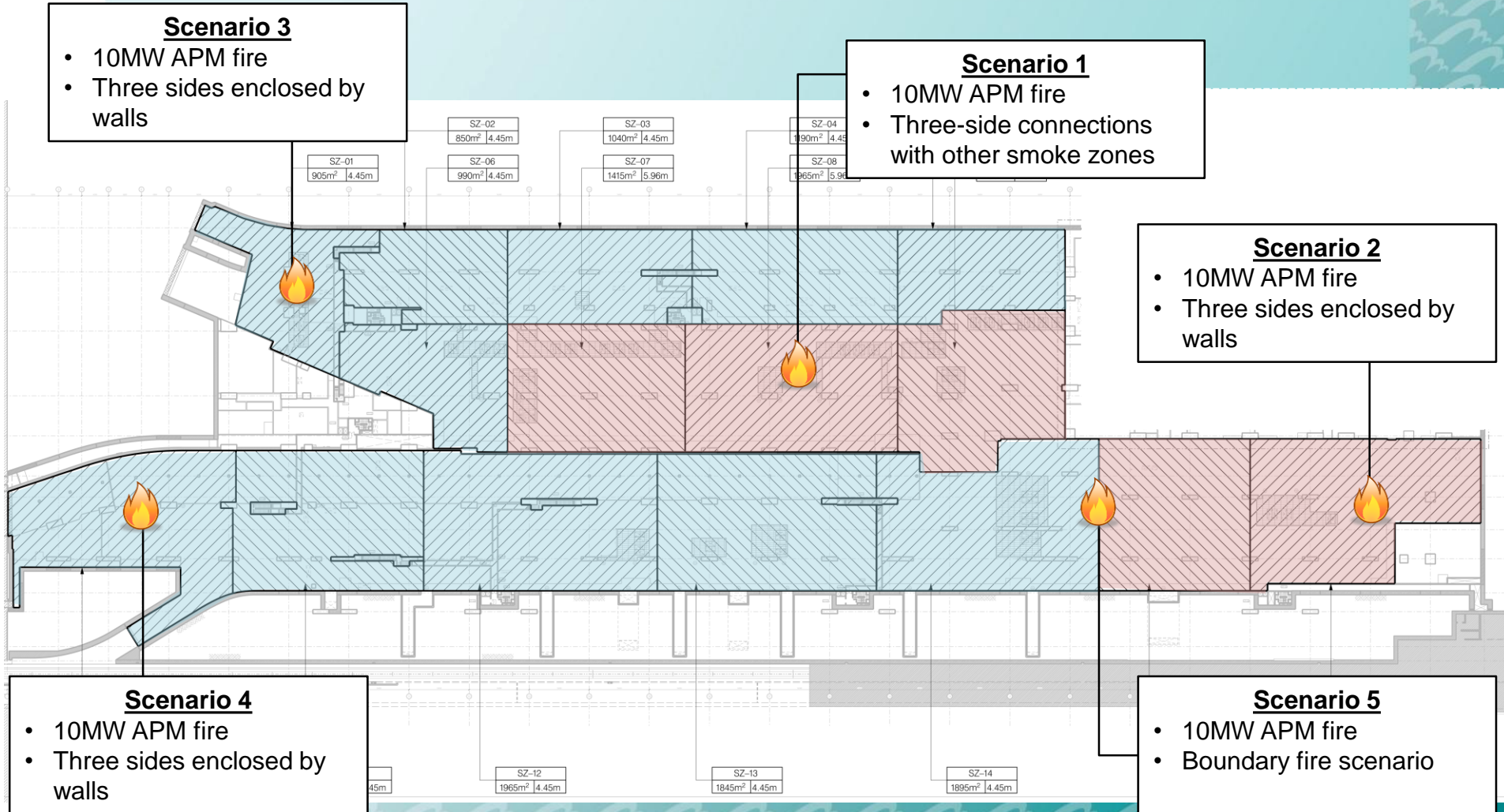
- 10MW APM fire
- Three sides enclosed by walls

Scenario 4

- 10MW APM fire
- Three sides enclosed by walls

Scenario 5

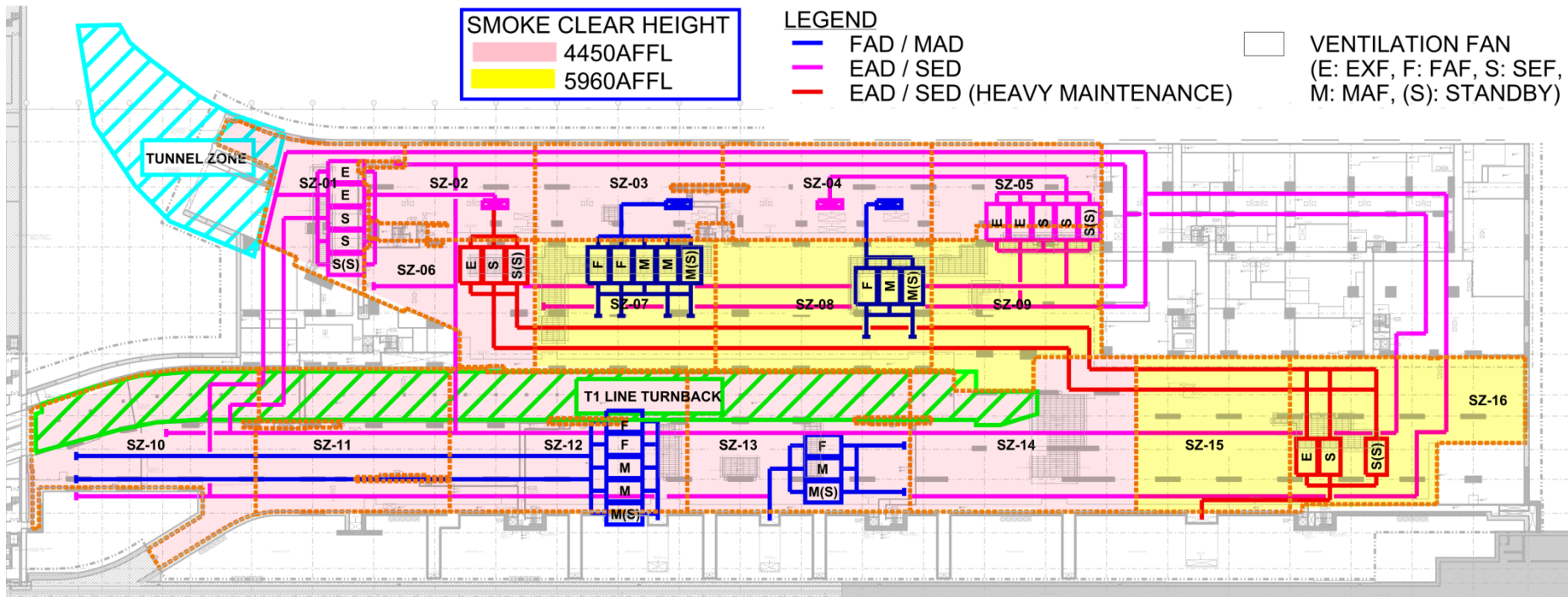
- 10MW APM fire
- Boundary fire scenario



Mechanical – Smoke Extraction System

Smoke Extraction System (Maintenance / Stabling Area)

- Dual purpose ductwork (SED / EAD), four dedicated smoke extraction plants, each plant comprises with N duty + 1 standby smoke extraction fan



Overview of Fire Engineering Approach

CFD Analysis

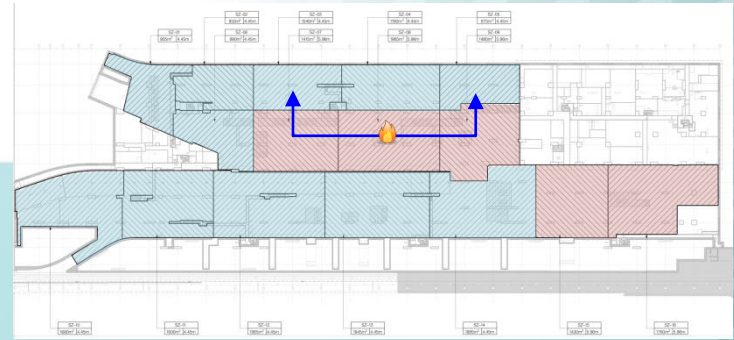
- Acceptance Criteria follows FS Code 2011

Items	Acceptance Criteria
Minimum smoke clear height	$\geq 2\text{m}$
Visibility at level below smoke clear height	$\geq 10\text{m}$
Temperature at level below smoke clear height	$\leq 60^{\circ}\text{C}$
Radiant heat flux	$< 2.5\text{kW}/\text{m}^2$ or about 200°C for the hot smoke layer at 2m above finished floor level
Carbon monoxide (CO) concentration at level below smoke layer height	$\leq 1,000\text{ppm}$

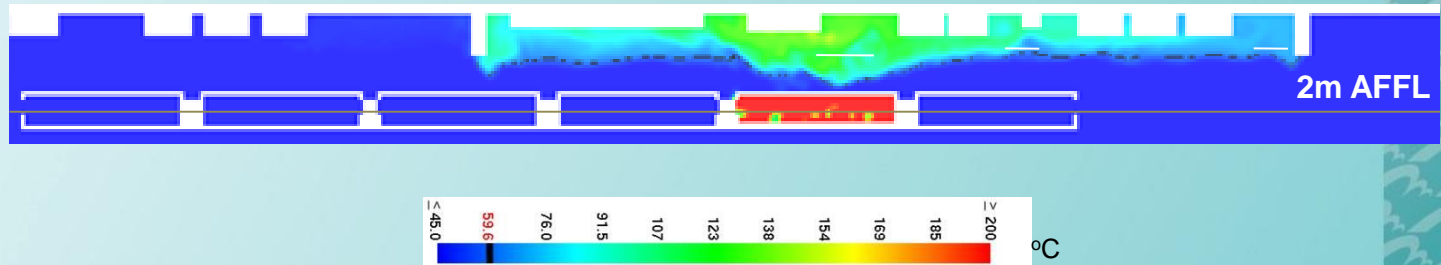
Overview of Fire Engineering Approach

CFD Simulation Scenario 1

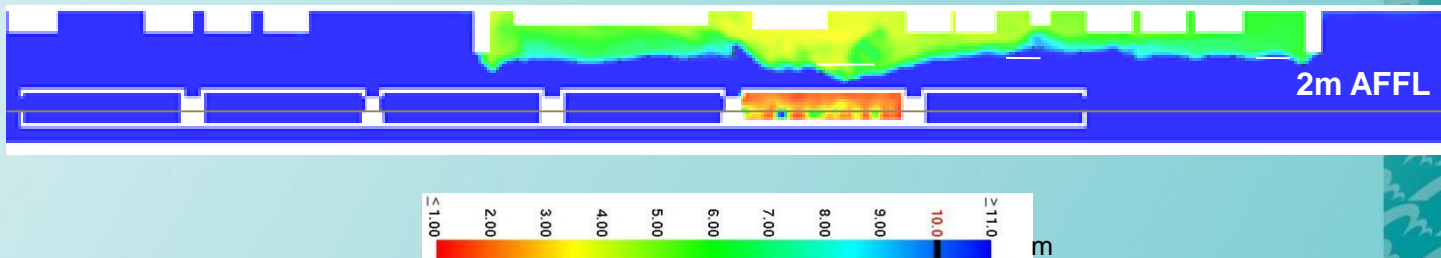
- CFD simulation results at steady state



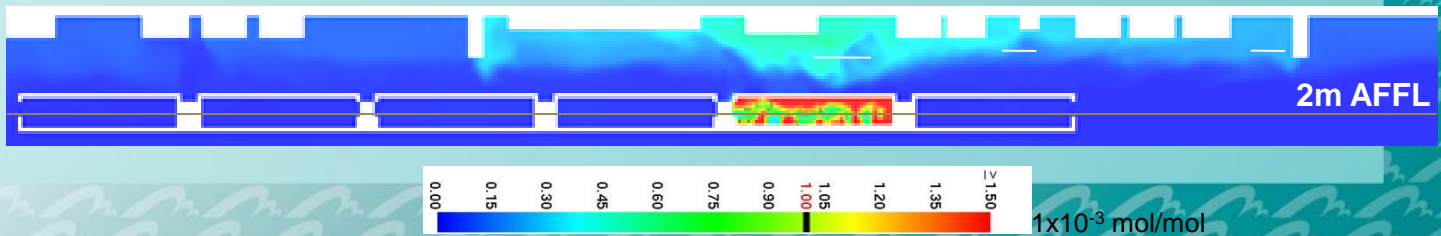
Temperature



Visibility



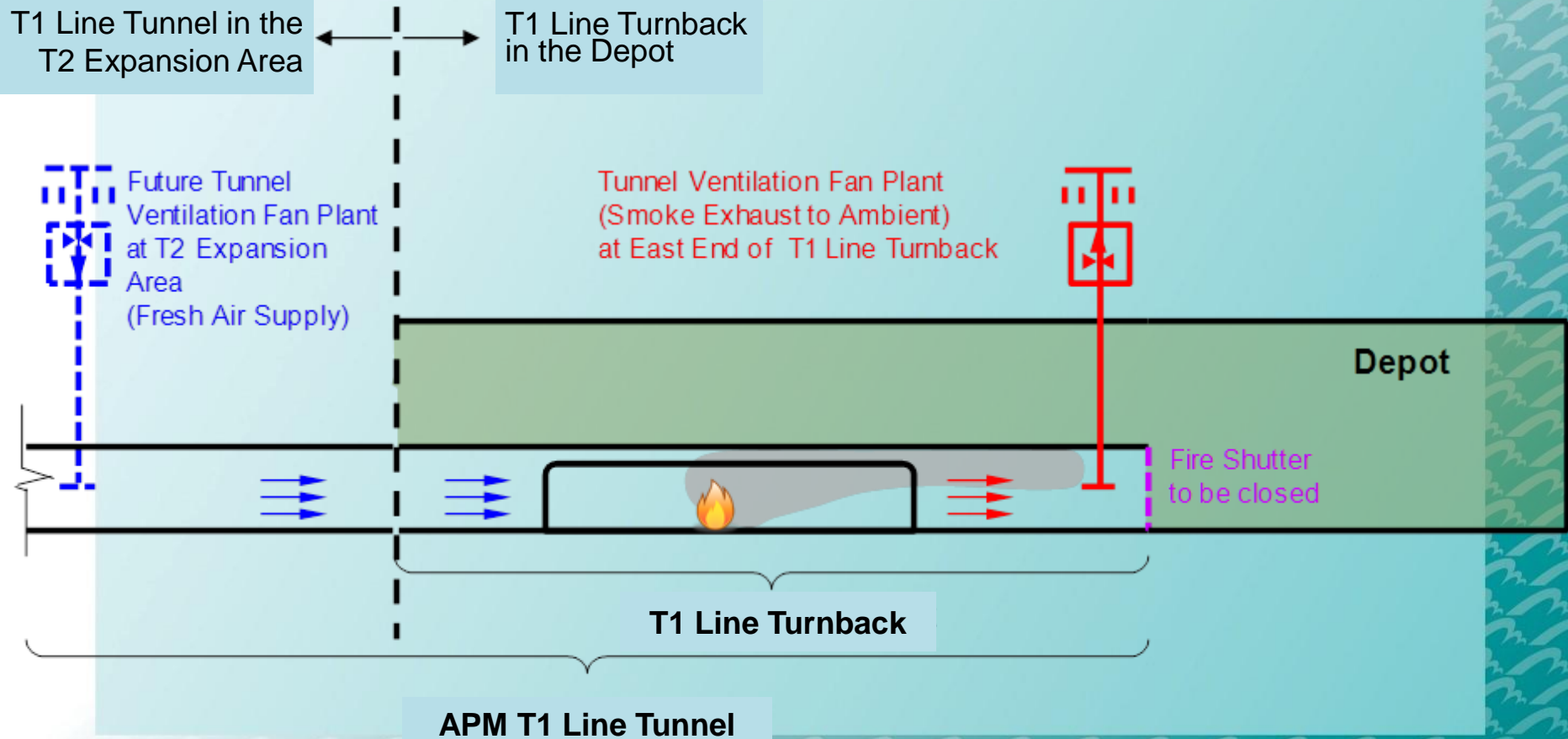
Carbon Monoxide



Overview of Fire Engineering Approach

T1 Line Turnback

- Push-pull longitudinal smoke control system
- Critical velocity = 1.6m/s
- Critical tunnel ventilation airflow = 82m³/s
- Smoke free on one side



Overview of Fire Engineering Approach

MoE Characteristics

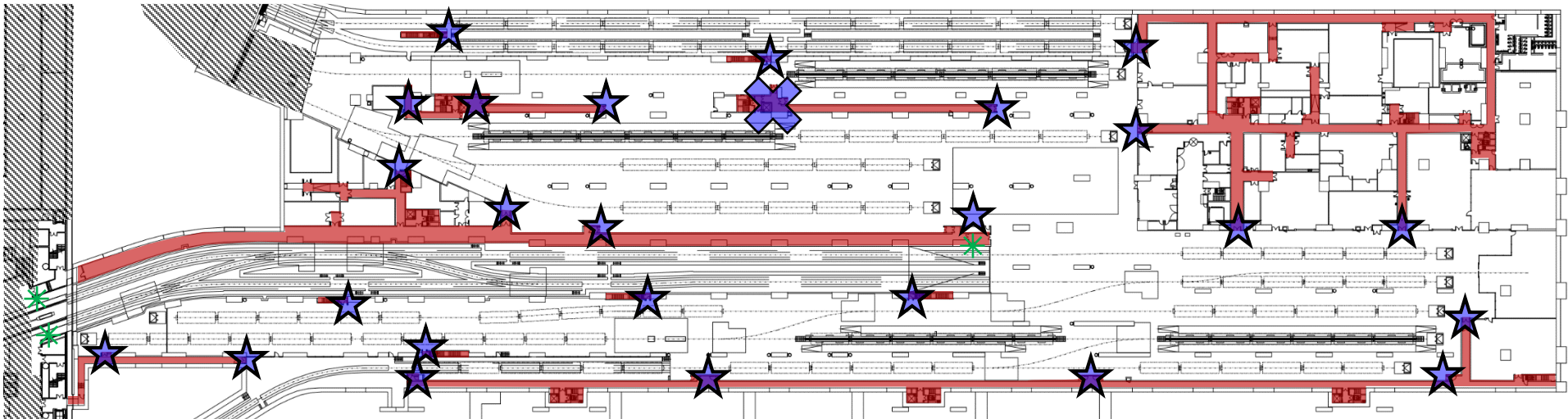
1. Low occupant capacity (60 staff per shift)
 - Density: $\sim 500\text{m}^2$ per staff
2. Extensive number of protected exits
 - Required: 2 numbers
 - Provided: ≥ 25 numbers for travel distance
3. Accessible to trained staff only

Overview of Fire Engineering Approach

Evacuation Analysis

Evacuation Scenarios

Scenario No.	Description
1	<ul style="list-style-type: none">All exits are available for use
2	<ul style="list-style-type: none">An exit used by the most evacuees in the Maintenance and Stabling Area in Scenario No. 1 is blocked by a fire
3	<ul style="list-style-type: none">Same as Scenario No. 2, except additional two maintenance staff working on the maintenance platform at high level



Key

Protected Corridor

Protected Exit of Maintenance and Stabling Area

Unavailable Exit in Evacuation Scenario No.2 and 3

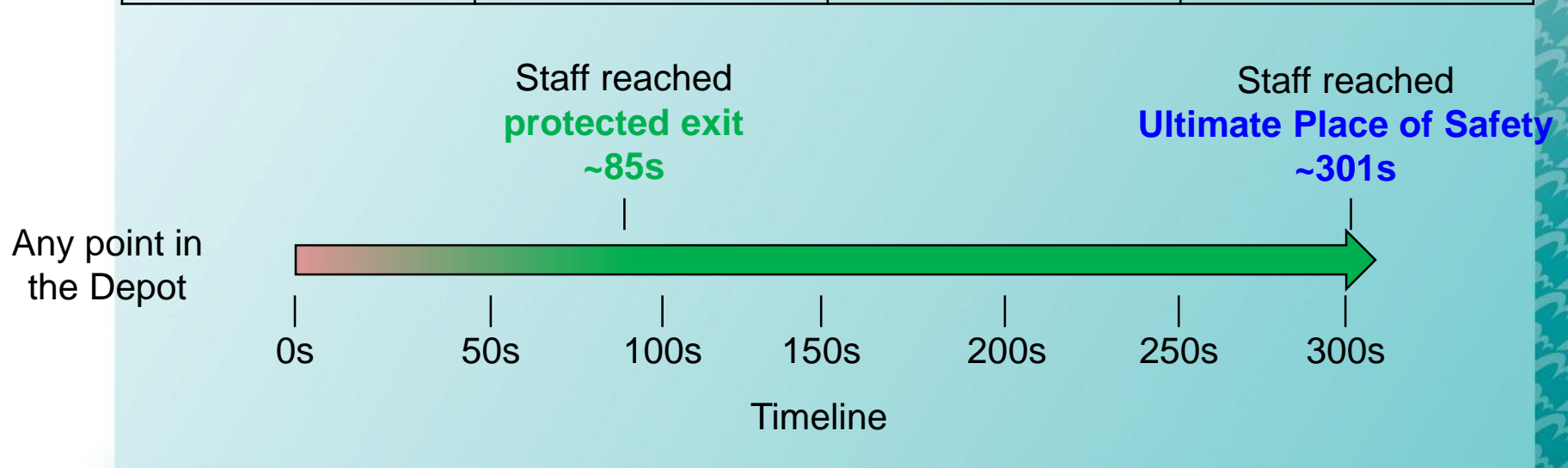
Exit Point of T1 Line Turnback

Overview of Fire Engineering Approach

Evacuation Analysis

- Computational Evacuation Model – Results

Evacuation Scenario No.	Physical Travel Time to Cat Ladder	Physical Travel Time to Protected Exit	Physical Travel Time to Ultimate Place of Safety
1	N/A	85s	301s
2	N/A	84s	309s
3	19s	86s	311s



Overview of Fire Engineering Approach

ASET/RSET Analysis

Parameter	Time
Time to raise a fire alarm (1)	172s
Pre-movement time (2)	90s
Physical travel time (3)	86s
RSET, (1) + (2) + (3)	348s
ASET	3,600s
Safety Factor (ASET / RSET)	10.3

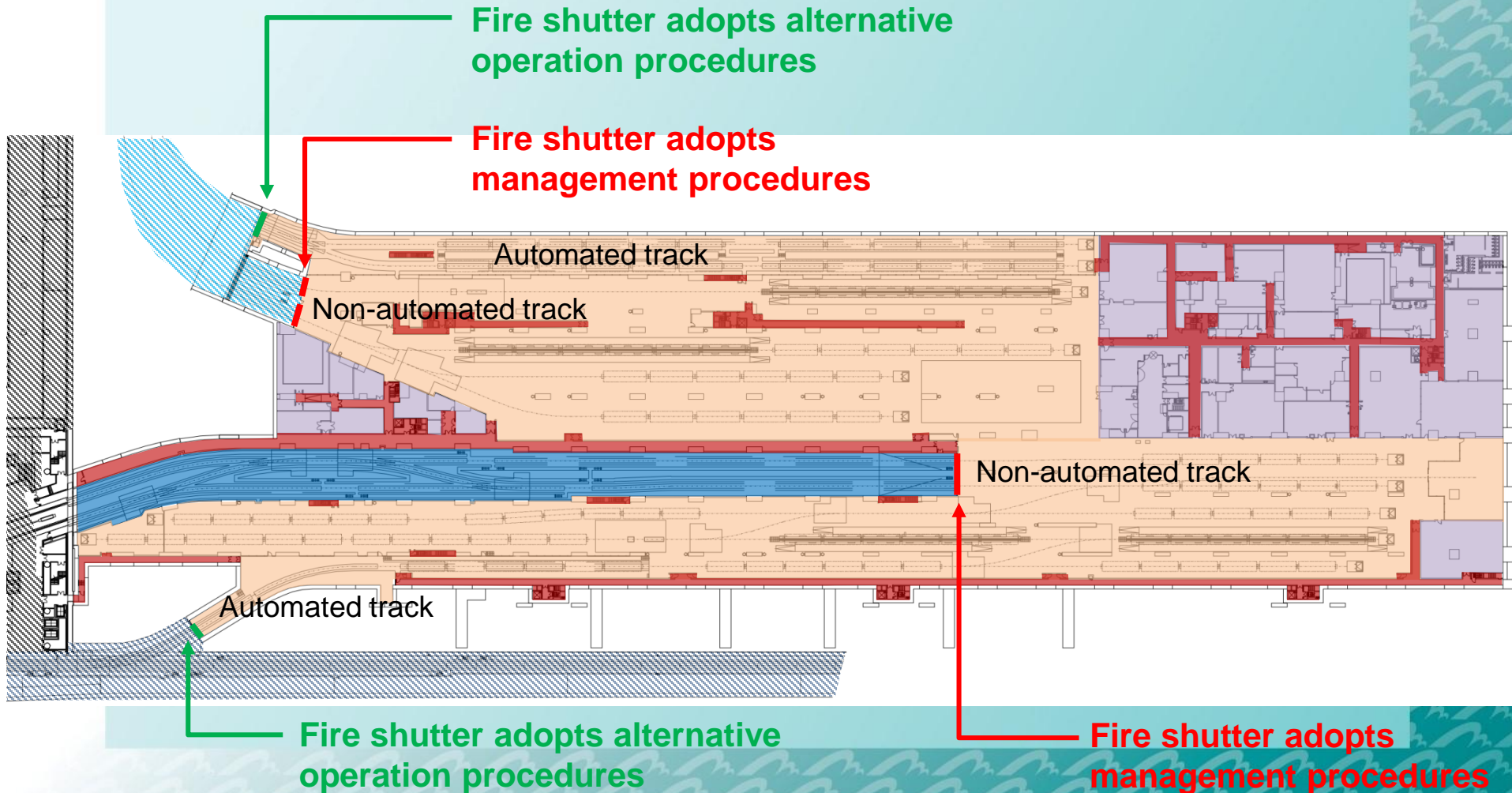


Timeline

Fire Shutter Operation

Measures to prevent collision between APM and fire shutter

- Non-automated track: Management procedures
- Automated track: Alternative operation procedures



Fire Shutter Operation

Non-automated track: Management procedures

Before APM passing through fire shutter line

- Ground technician to present at the fire shutter lines
- Ground technician, operator in APM Central Control Room and APM vehicle operator to inform each other the next action to be carried out

During APM passing through fire shutter line

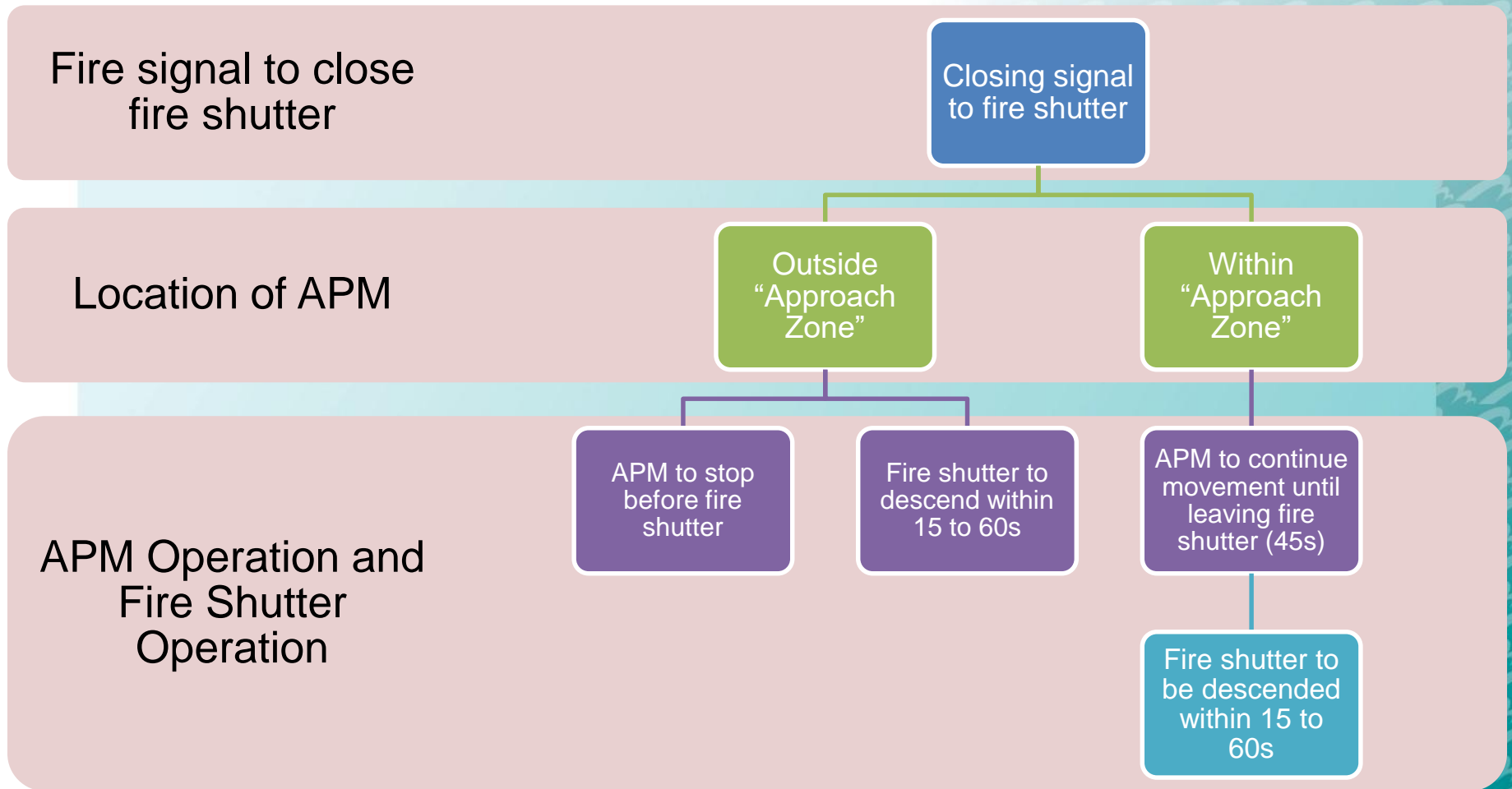
- Ground technician to push and hold the “stop” button of fire shutter continuously

After APM passing through fire shutter line

- Ground technician to check the APM passed the fire shutter line
- Ground technician to release the “stop” button of fire shutter

Fire Shutter Operation

Automated track: Alternative operation procedures



“Approach Zone”: This zone is defined as a distance from the fire shutter in which a 6-car APM, travelling at the allowed speed, would be able to stop before the line of fire shutter, assuming worst-case braking profile.

6

Fire Safety Management Plan

Fire Safety Management Plan

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graph TD; A[Fire Safety Management Plan] --- B[Fire Action Plan]; A --- C[Maintenance Plan]; A --- D[Training Plan];
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Fire Safety
Management Plan

Fire Action Plan

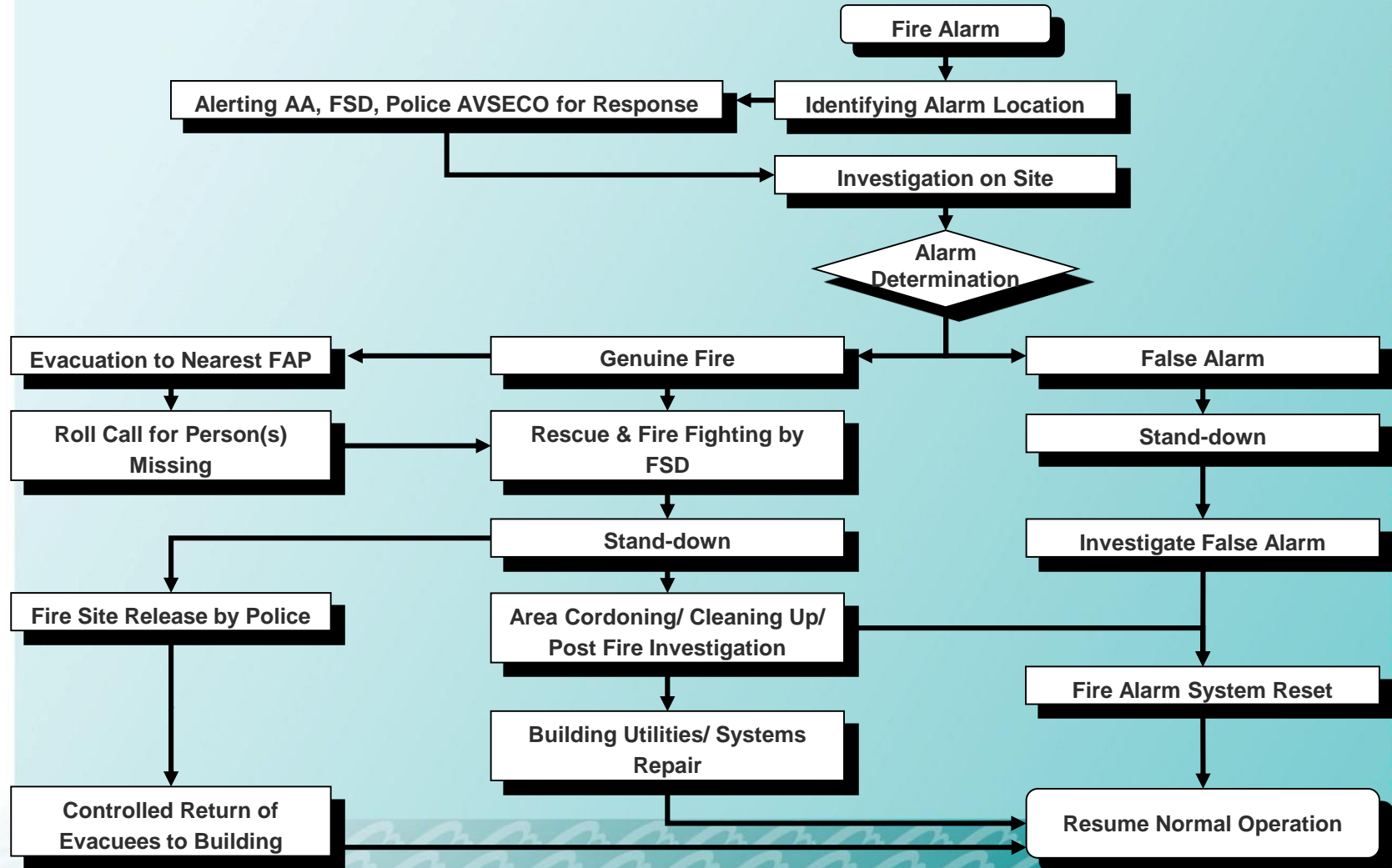
Maintenance Plan

Training Plan

Fire Safety Management Plan

Fire Action Plan:

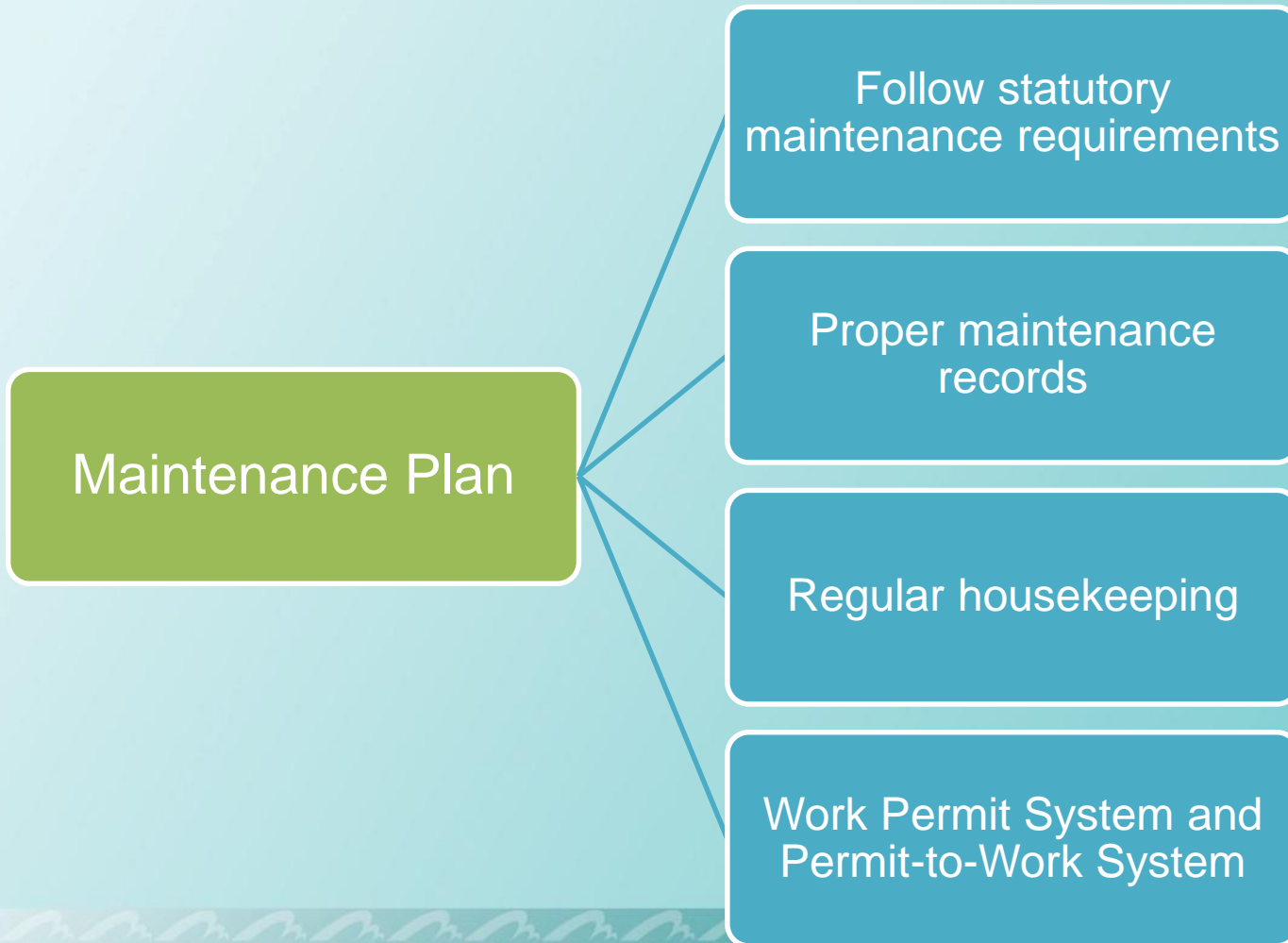
- To work out and document the predetermined procedures for all parties to follow in the event of a fire emergency



Fire Safety Management Plan

Maintenance Plan

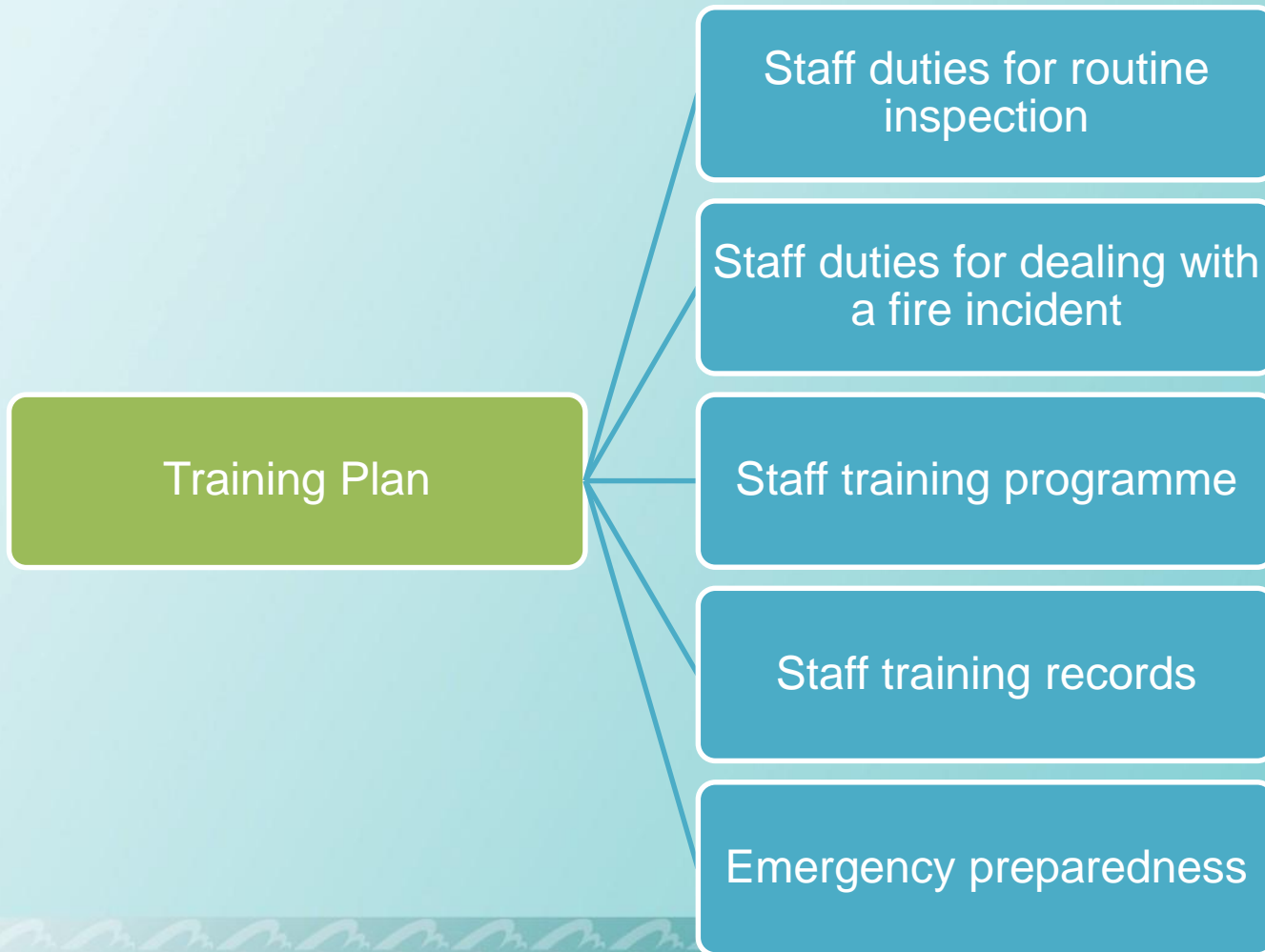
- To document the periodic maintenance requirements so that fire safety provisions are kept in good working order



Fire Safety Management Plan

Training Plan

- To ensure staff are familiar with the fire safety provisions installed and the actions to be taken in case of fire



Thank You