PROCEEDINGS, Fire and Evacuation Modeling Technical Conference (FEMTC) 2022
September 12-14, 2022

L&T Construction

Evaluation of Engineered Smoke Management System for an International Airport Expansion Project Using PyroSim/FDS

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- Smoke management strategy
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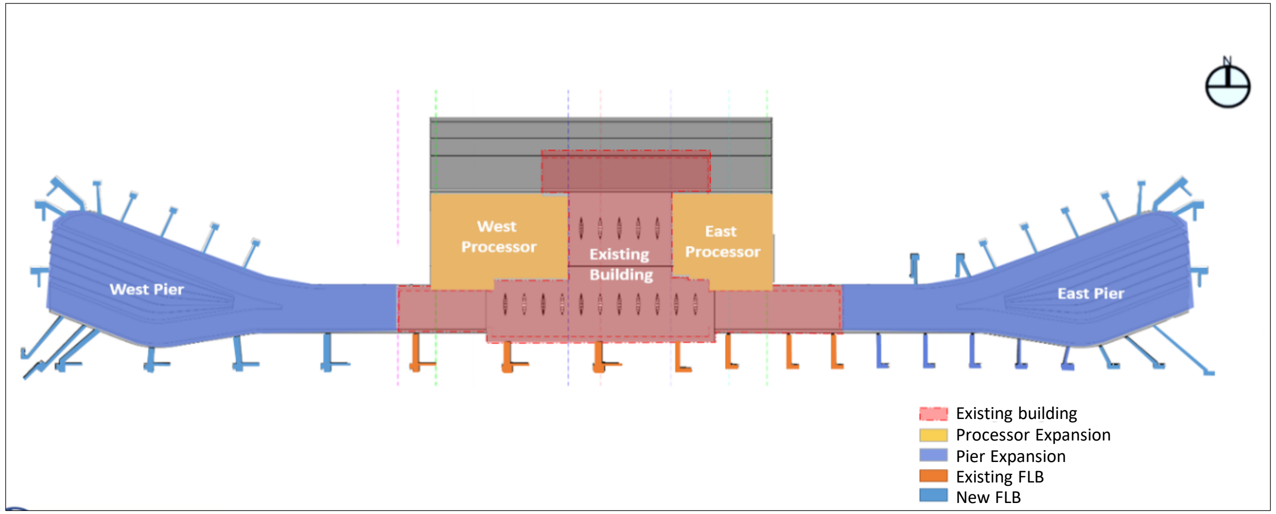
- Control of smoke spread
- CFD tool – PyroSim/FDS

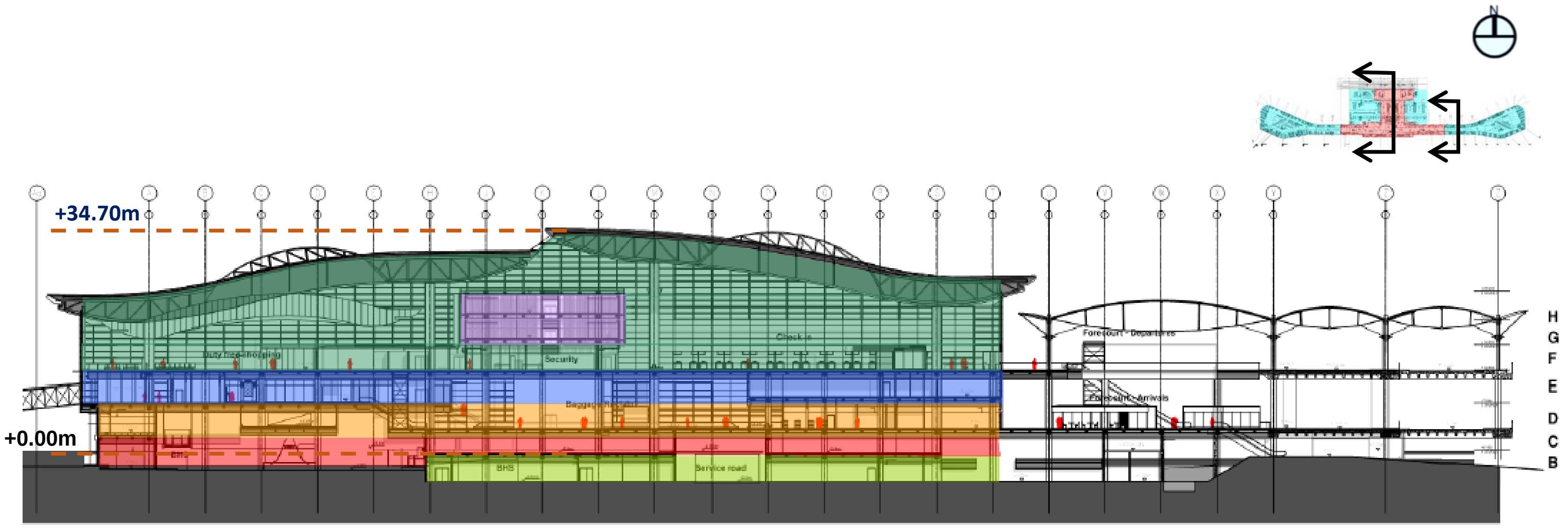
02 BUILDING DESCRIPTION

- Airport expansion
  for 3X passenger capacity
- Multi level Passenger Terminal Building (PTB)
- Level D for Baggage reclaim area and Level F for Check-in hall

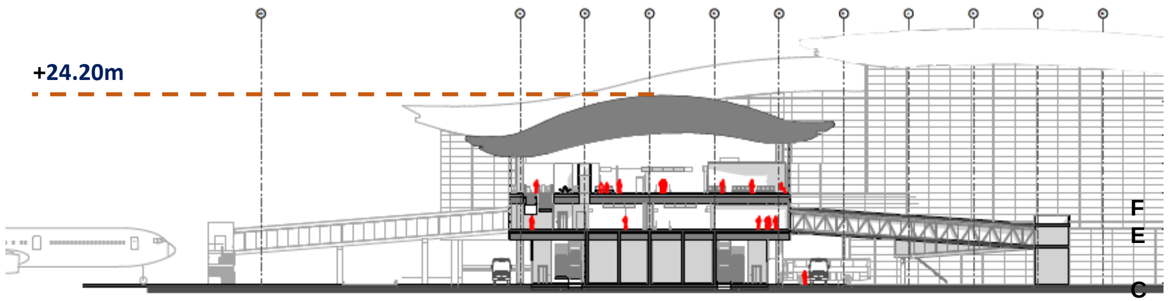


02 BUILDING DESCRIPTION – contd..

- T-shaped building
- 7 levels and 2 piers
- Extension of Processor and Piers (West and East Wing)



Processor Section



Pier Section

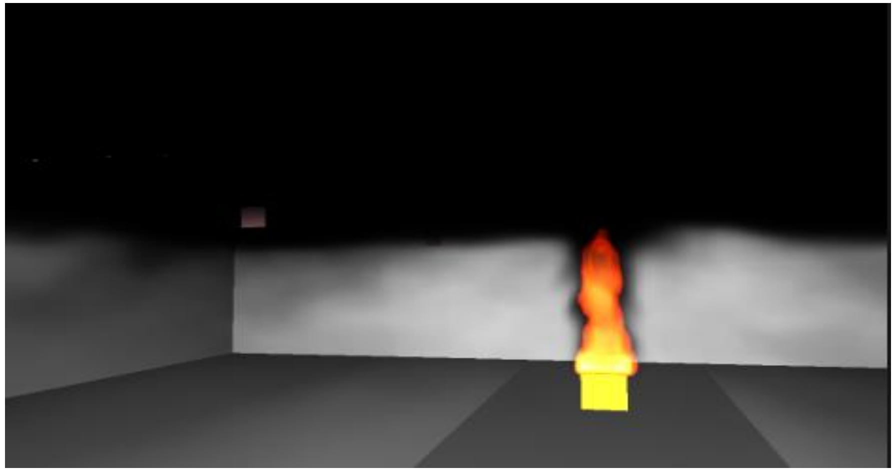
Levels:

Level F : +12.50
Level E :+08.50/+07.50
Level D : +03.50
Level C : -00.40/+00.15
Level B : -05.00

Note: All Levels are in Meter

03 OBJECTIVE

Performance based engineering approach for life safety in PTB



- Adequacy of smoke management system
  - Design fire size
  - Smoke spread
  - Visibility levels

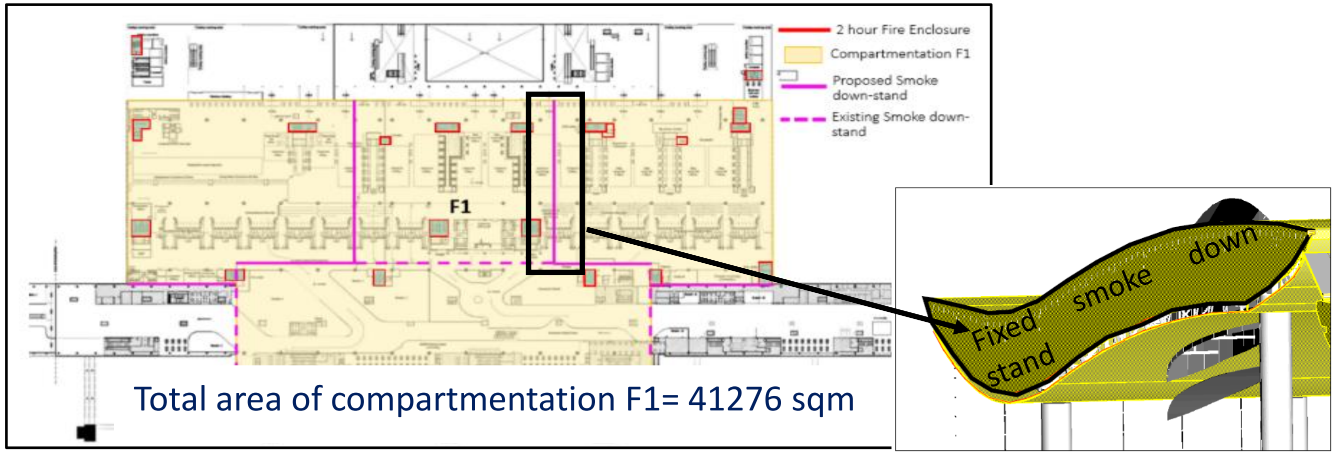
- Level D Baggage reclaim area

- Level F Check-in hall

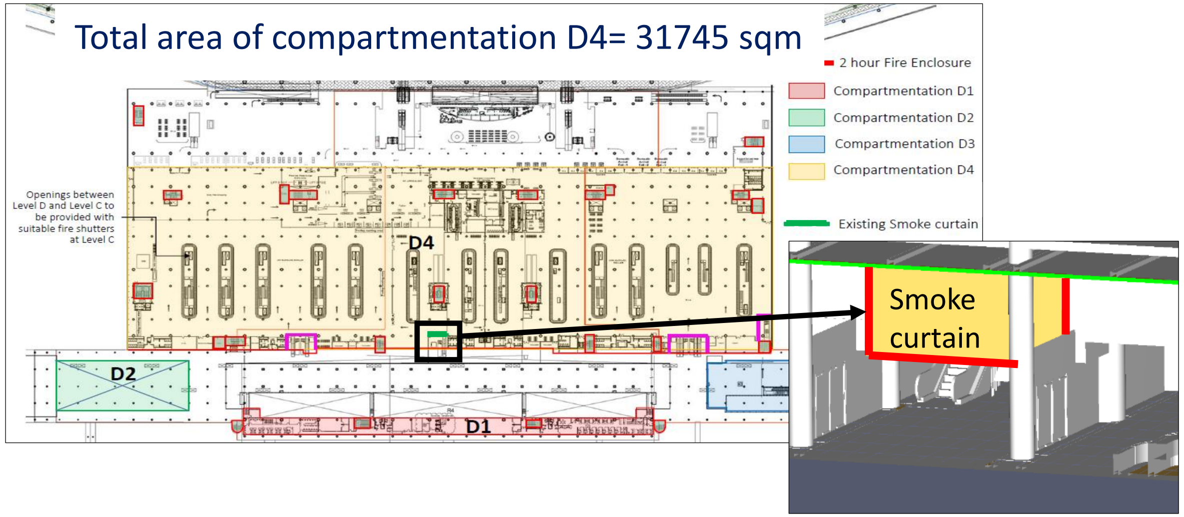
04 METHODOLOGY

<u>Smoke management system</u>

- Every 2000sq.m – to be compartmented?
- Level F (Processor) -> 21 compartments!
- Level D (Processor) -> 16 compartments !
- Intended use – not served…..!
- Solution – smoke management system
    - smoke zones (21- > 4, 16 -> 1)
    - Smoke vents
    - Smoke down stands
    - Smoke curtains



Compartmentation - Level F (Processor)



Compartmentation – Level D (Processor)

04 METHODOLOGY– contd..

Smoke management system

- Smoke free zone of specified height and level of safety

- Natural vents (i.e., static smoke extraction system)
    - Maintain tenable conditions
    - Limit smoke spread
    - Limit smoke damage

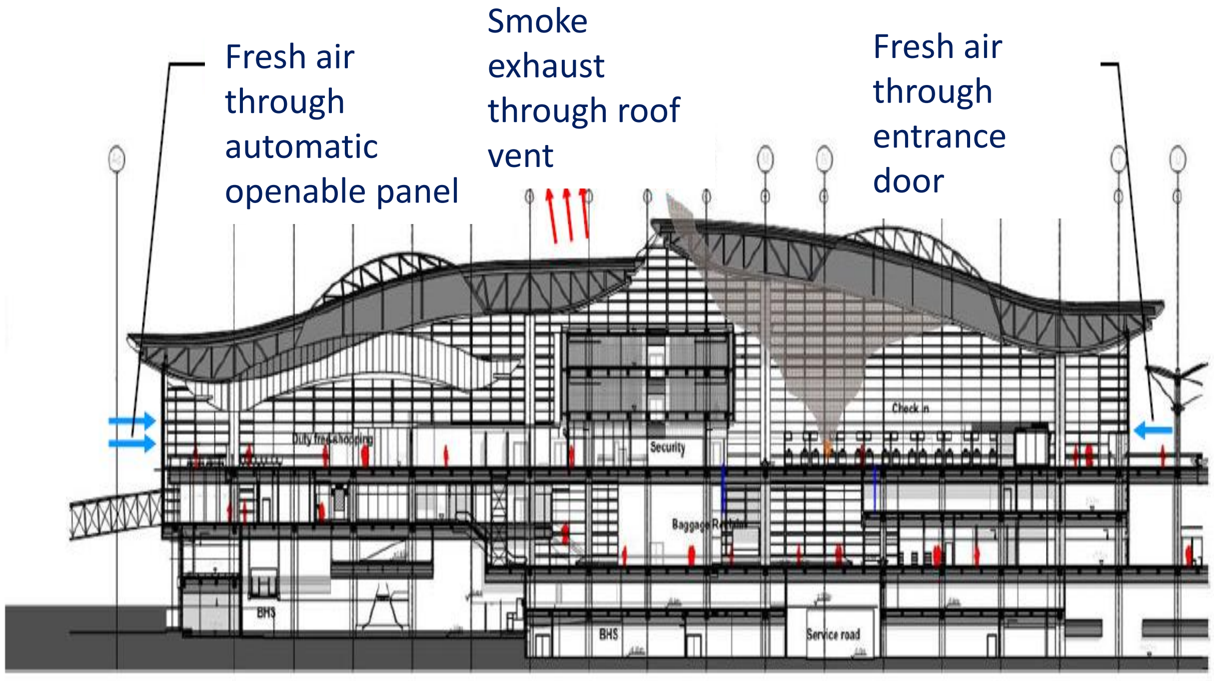
Why natural vents?
the flexibility of the PTB for future development is maximized.

Source : SOLIDOME Skylight domes and roof hatches

04 METHODOLOGY – contd..

Smoke extraction system

- Automatic openable vents on roof or on facades.
- Make-up air via the entrance doors and automatic openable panels.
- Roof vents and automatic openable panels activated immediately on activation of smoke detection.
- Fixed down stand between each smoke zone in the processor. will drop from the roof to 450 mm above the ceiling
- Smoke curtain between two compartment zones, will drop to 2.5m from floor to restrict the smoke spread.



Processor Section

04 METHODOLOGY – contd..

Fire loads

- High fire load area

  e.g., Retail area

- Low fire load area

  e.g., Circulation space, seating space, baggage area and check - in counter

Design Fires:

S.no	Level	Design Fire	Fire Size (MW)	Soot yield (kg/kg)
1	Level F - Processor	Check-in counter	3.6	0.1
2	Level D - Processor	Baggage	2.5	0.1

External wind effect

As per the airport location, based on average statistics for wind speed and monthly wind direction percentage, maximum wind velocity is 5.2 m/s from west direction is considered as wind effect on smoke spread for CFD analysis

04 METHODLGY – contd..

Tenability conditions:

Criterion	Tenability limit
Smoke layer height	Smoke to be kept at 2m above floor*
Visibility	Occupants will not be exposed to smoke with visibility of 10m or less**
Temperature	If smoke is maintained at 2m above floor level, the smoke temperature should be kept at 185 ^{0}C or less*** If smoke drop to 2m or less, smoke temperature should be kept at 60^{0}C or less****

* When the hot layer is at or below 2.0m above the floor level and simultaneously the hot layer temperature exceeds 100°C, the occupants will feel their lives are being threatened on such conditions (CIBSE Guide E).

** Where there is a clearly defined escape route a visibility of 10 m is normally considered reasonable (CIBSE Guide E).

*** When the hot layer is at 2 m above the floor and the temperature exceeds 185°C, the radiation emitted from the hot smoke layer will cause severe skin pain. (CIBSE Guide E).

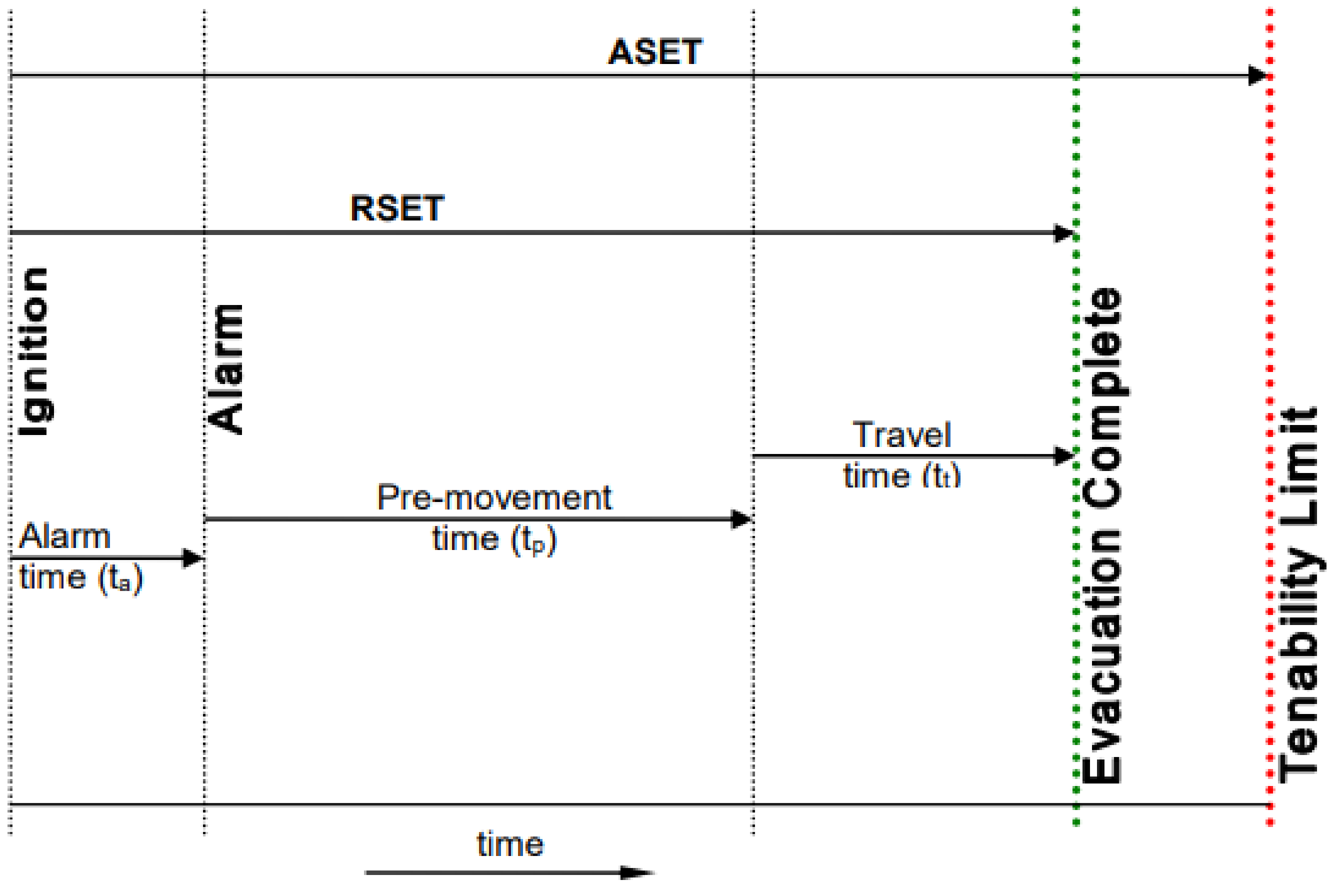
*** As shown in SFPE Handbook, 80°C is the thermal tolerance for human for long time exposure in dry air and 60°C is for the humid air. A temperature of 60°C is also the reportable highest temperature at which 100% water-vapor saturated air can be breathed. Therefore, 60°C is conservative tenability criteria.

04 METHODOLOGY – contd..

Life safety assessment

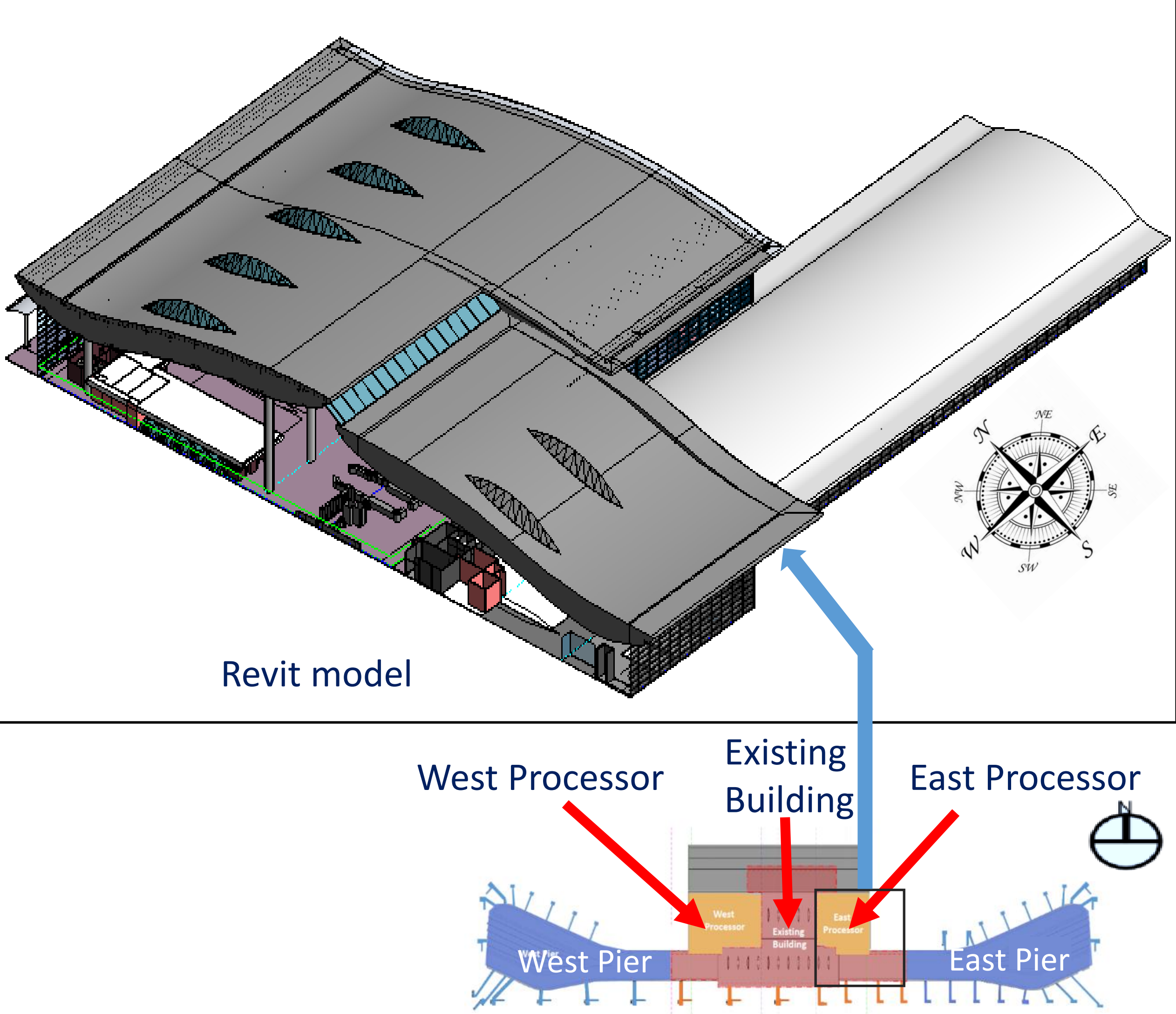
The evaluation of safe egress time:

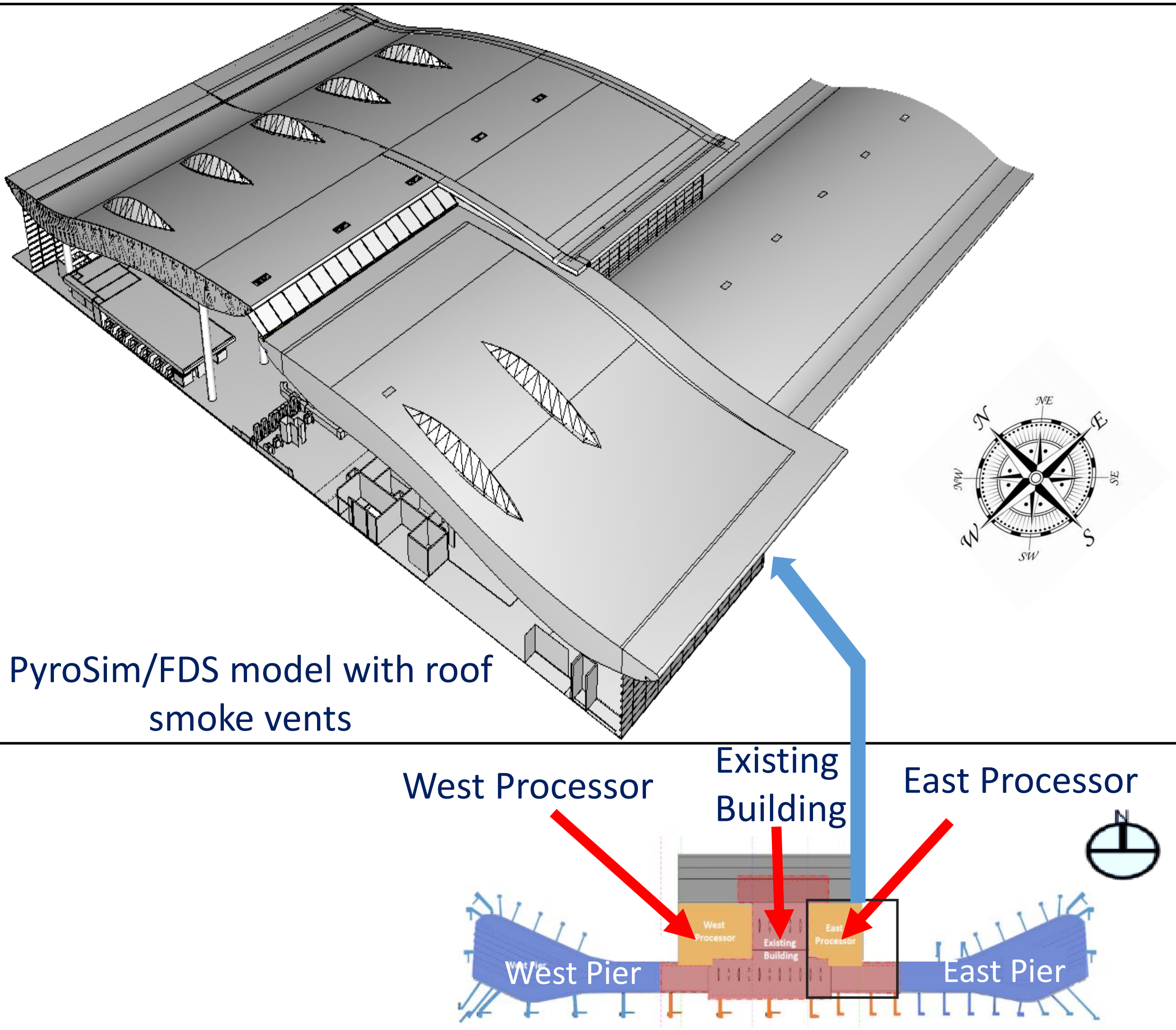
- ASET (Available safe Egress Time) - from CFD
- RSET (Required safe Egress Time) – from egress calculations
- For safe evacuation: ASET >1.5 RSET



PyroSim/FDS MODELS

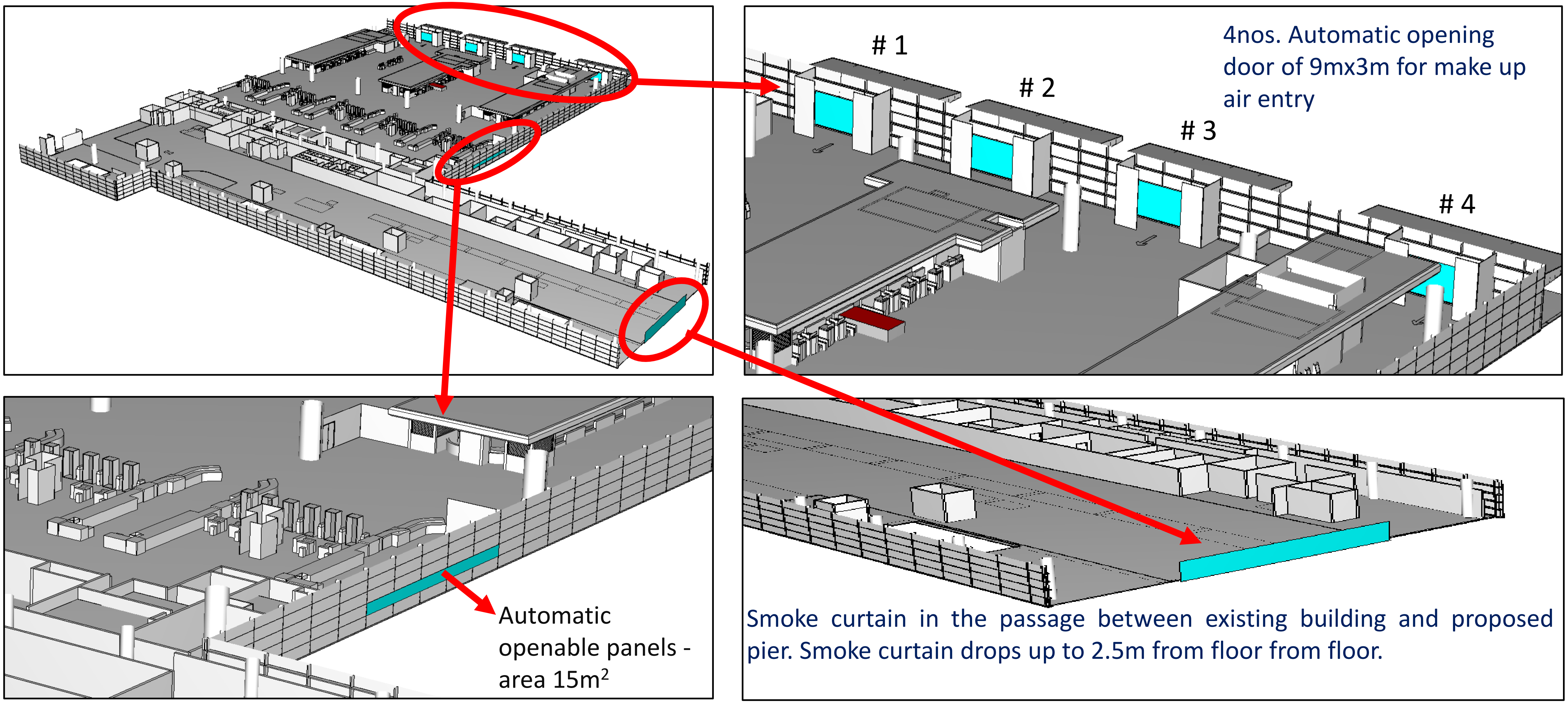
Level F East Processor model





PyroSim/FDS MODELS

Level F East Processor model



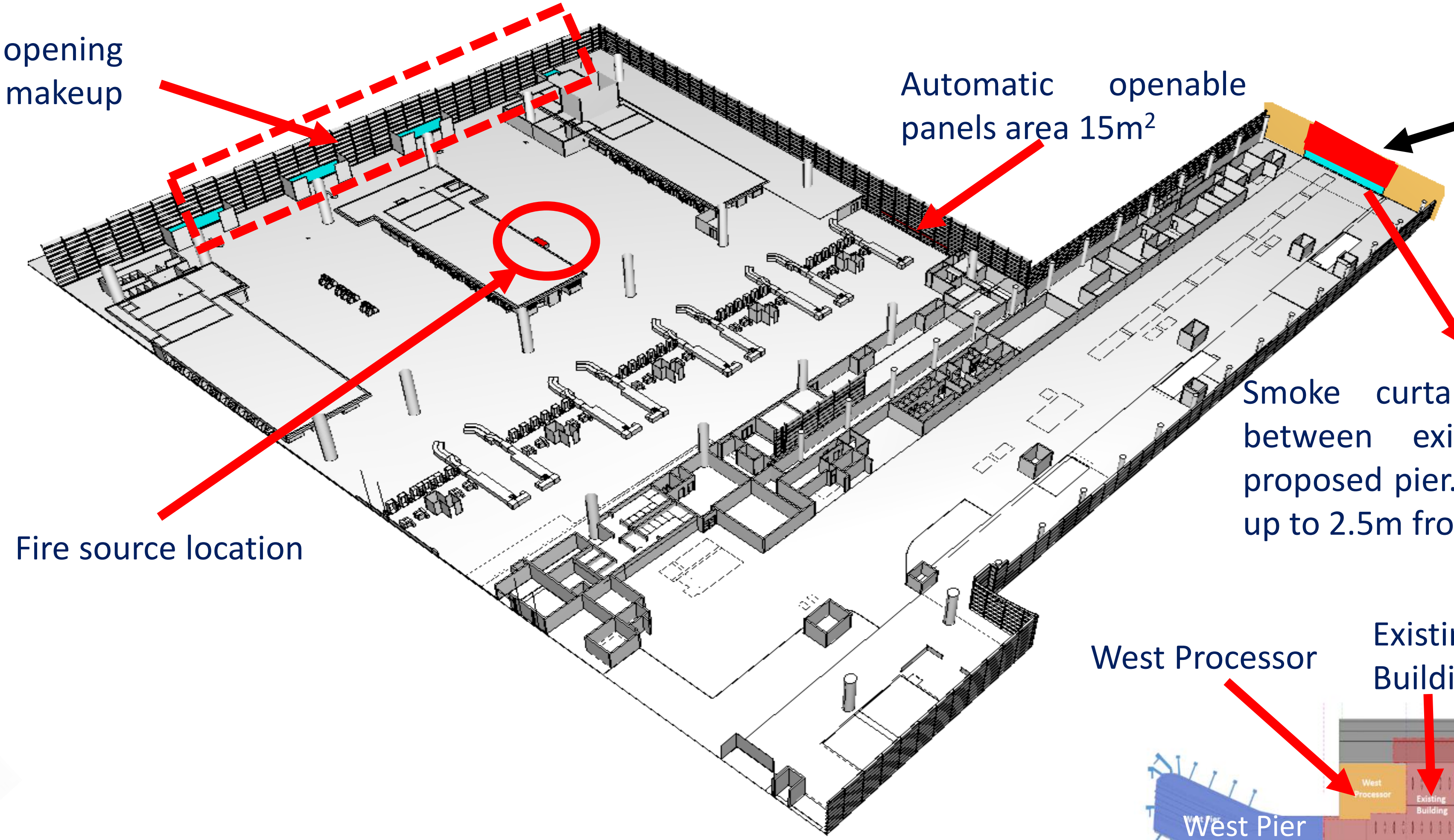
PyroSim/FDS MODELS

Level F East Processor model

4nos. automatic opening door of 9mx3m for makeup air entry

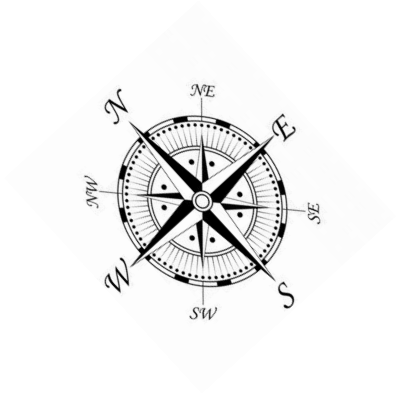
Automatic openable panels area 15m²

Smoke curtain



Fire source location

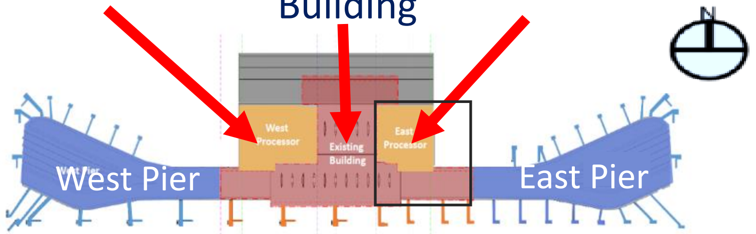
Smoke curtain in the passage between existing building and proposed pier. Smoke curtain drops up to 2.5m from floor.



West Processor

Existing Building

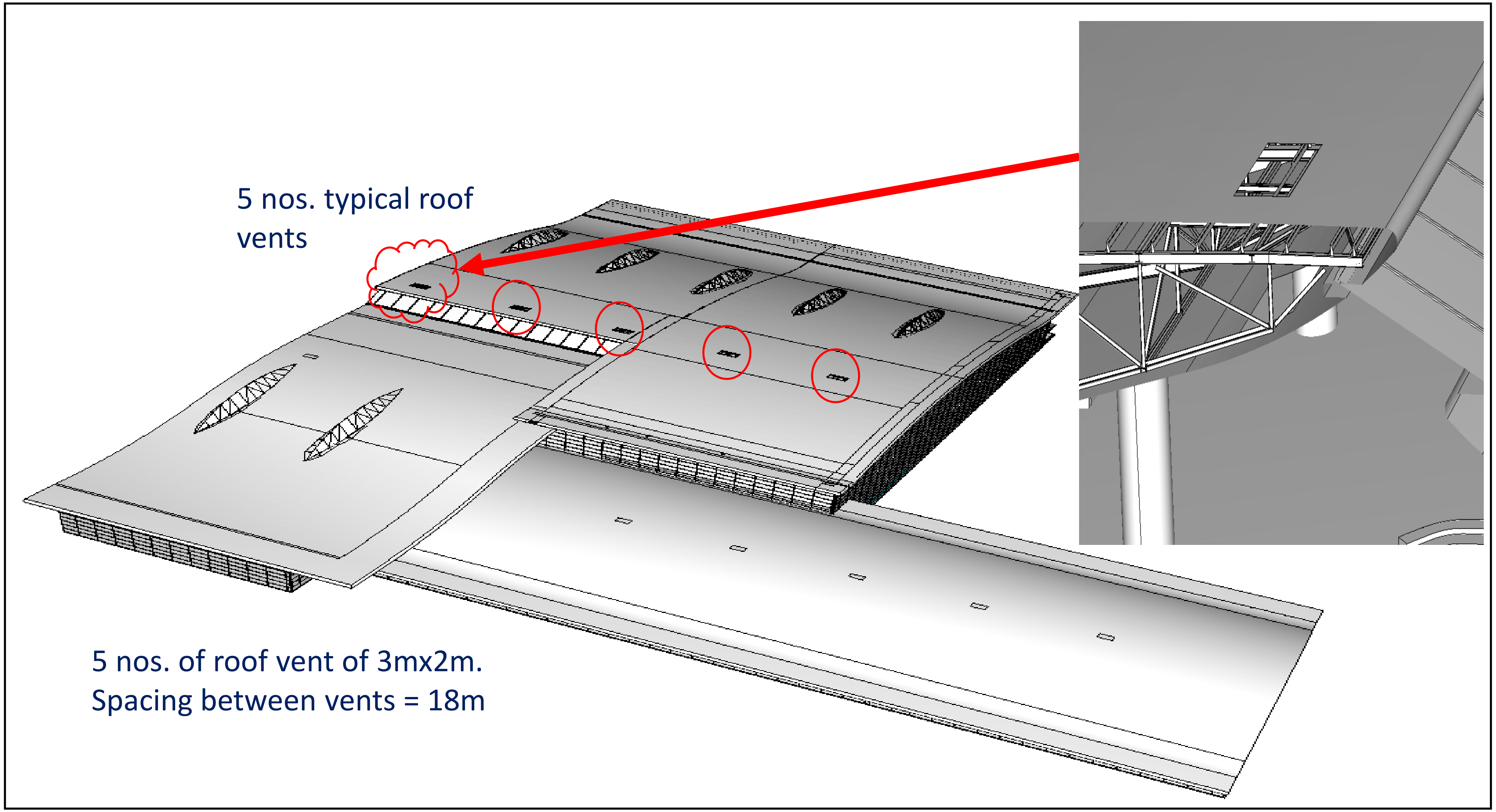
East Processor



Level F East Processor with roof hidden

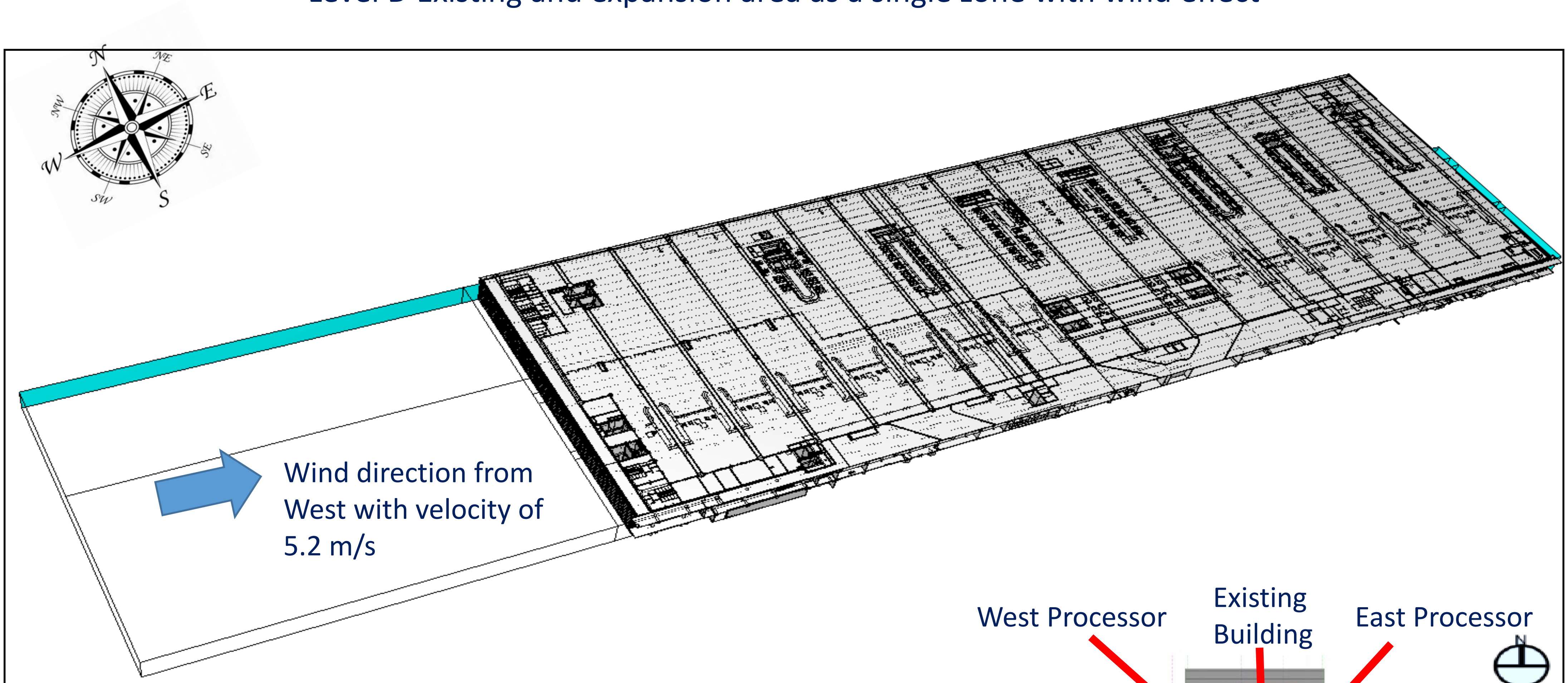
PyroSim/FDS MODELS

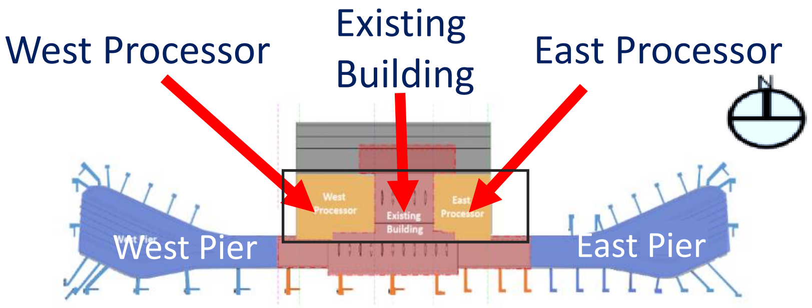
Level F East Processor model



PyroSim/FDS MODELS

Level D Existing and expansion area as a single zone with wind effect





PyroSim/FDS MODELS

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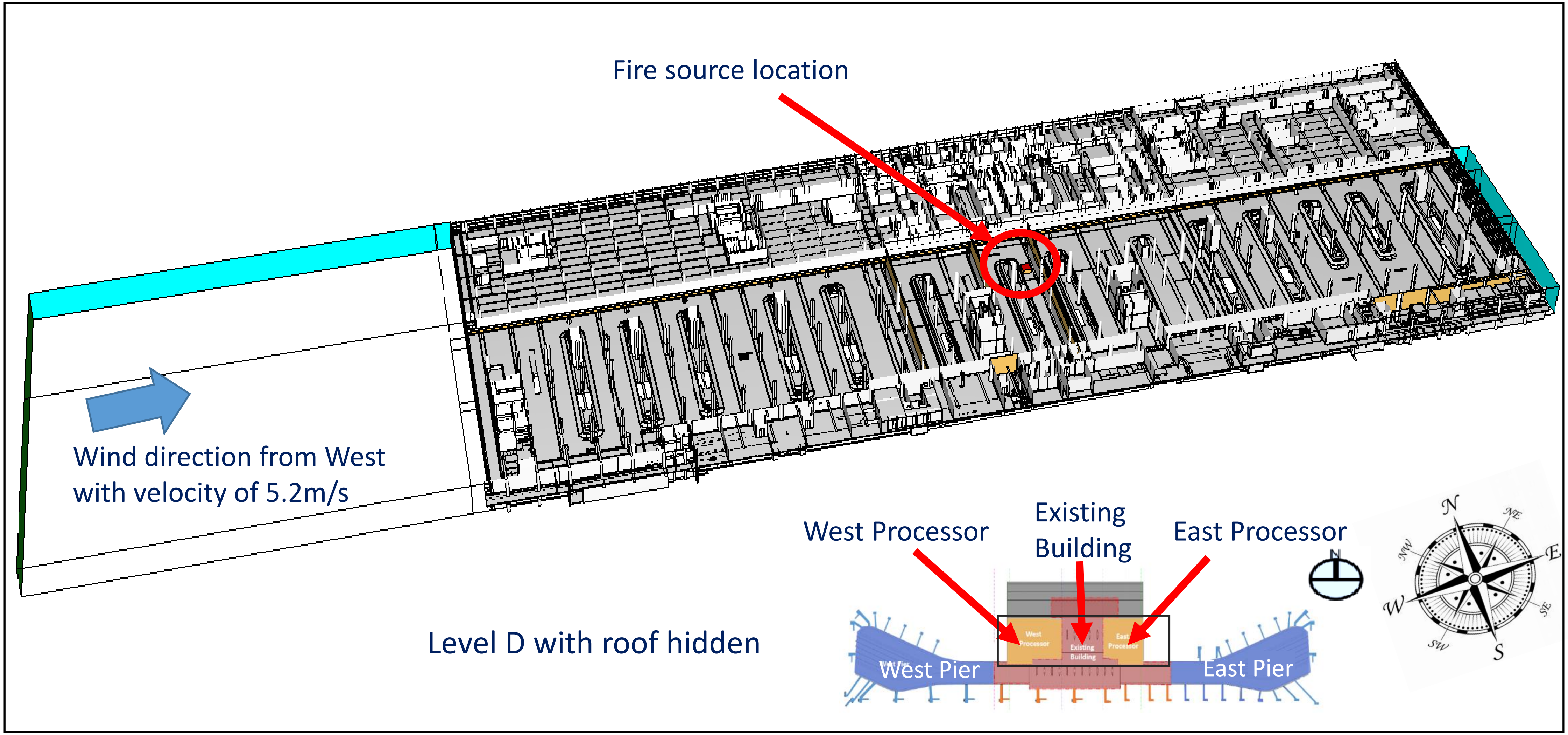
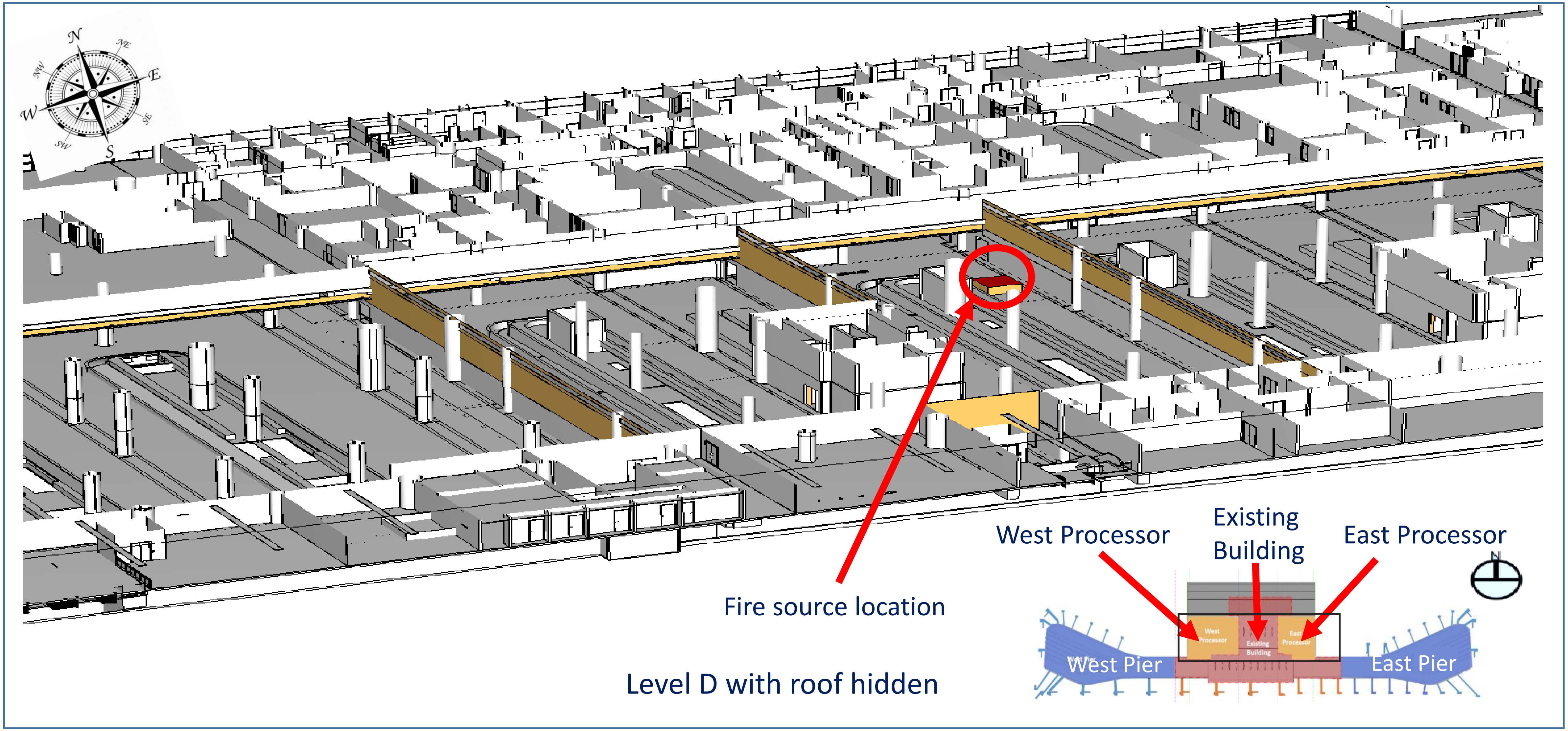


PyroSim/FDS MODELS

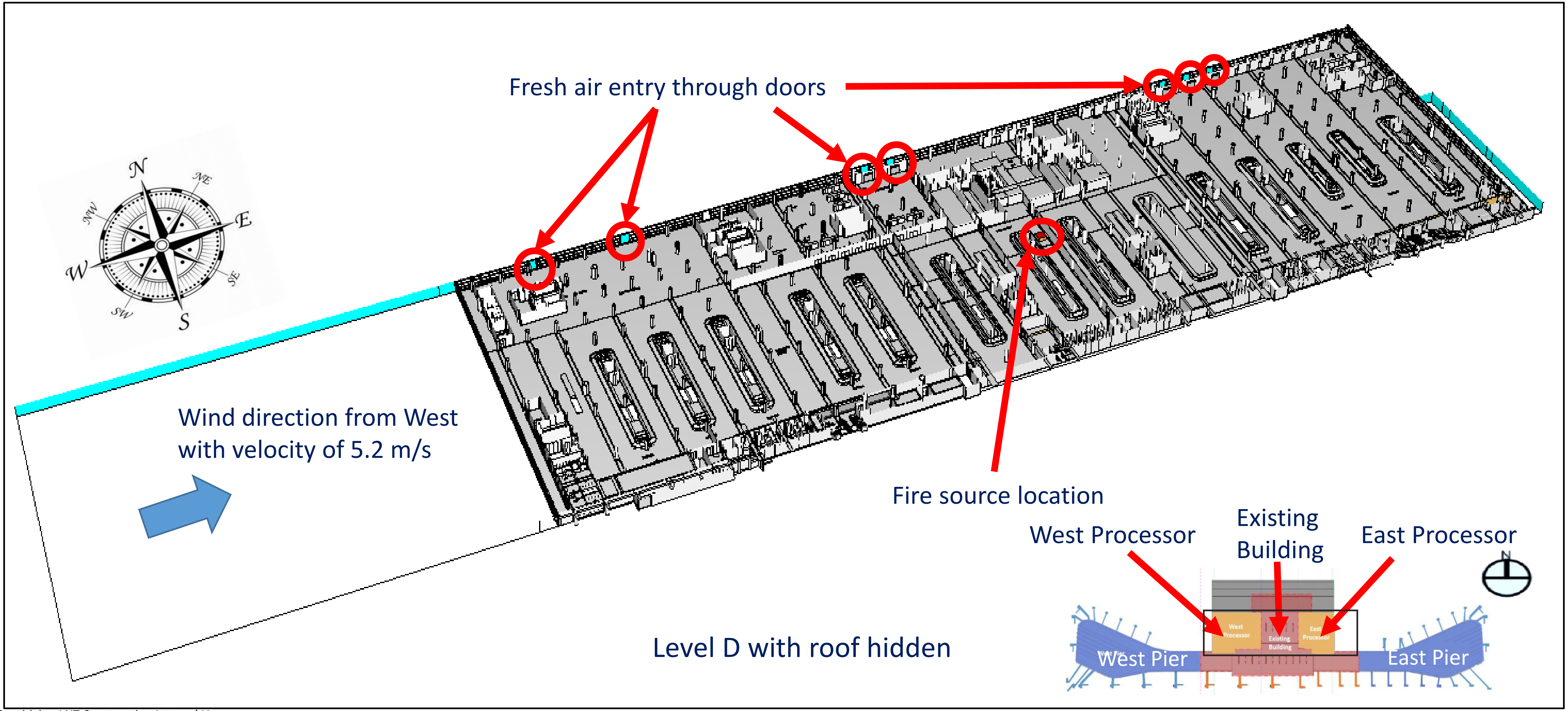
Level D Existing and expansion area as a single zone with wind effect



Level D with roof hidden

PyroSim/FDS MODELS

Level D Existing and expansion area as a single zone with wind effect

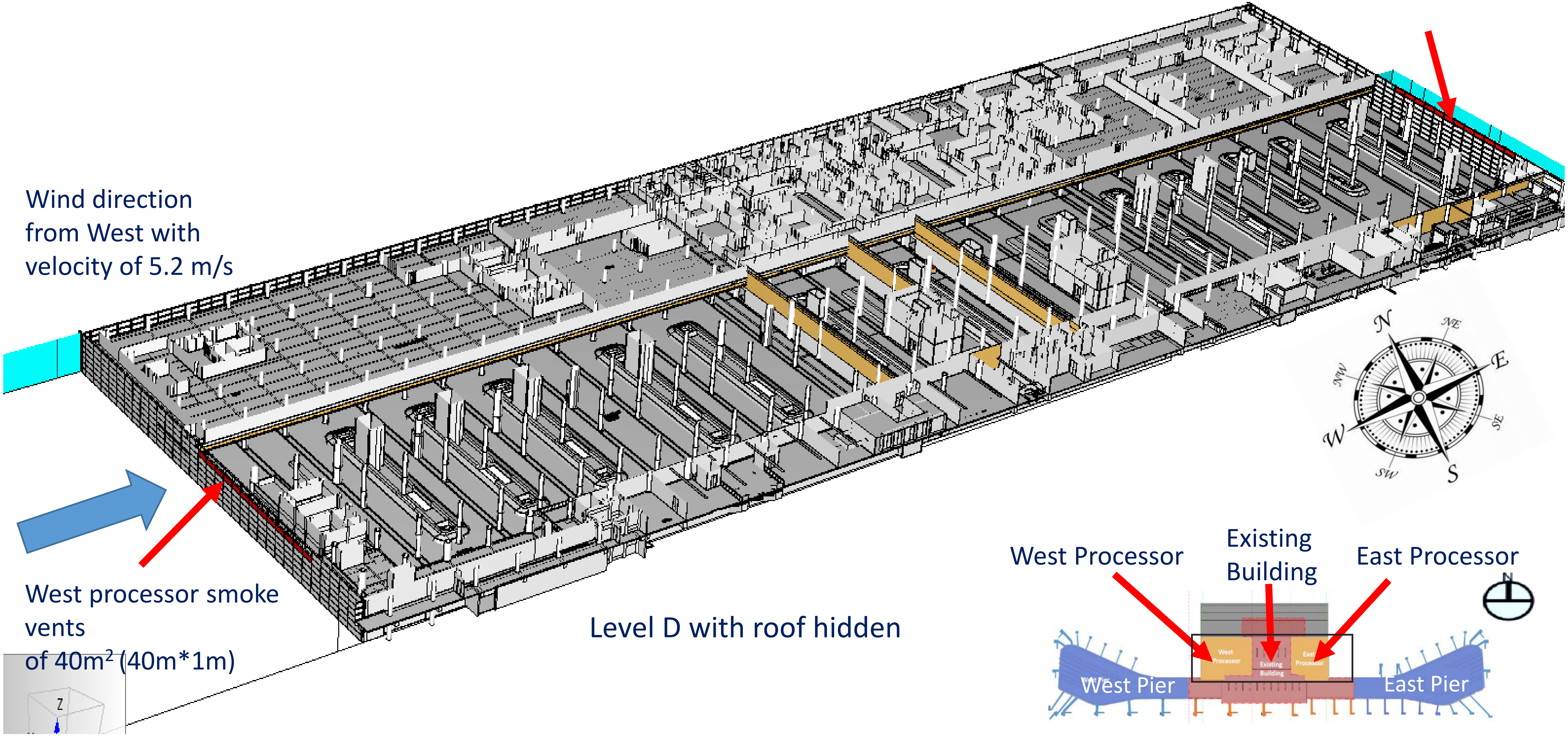


PyroSim/FDS MODELS

Level D Existing and expansion area as a single zone with wind effect

East Processor Smoke vents of 40m^2 (40m*1m)

Wind direction from West with velocity of 5.2 m/s



West processor smoke vents
of 40m^2 (40m*1m)

Level D with roof hidden

West Processor

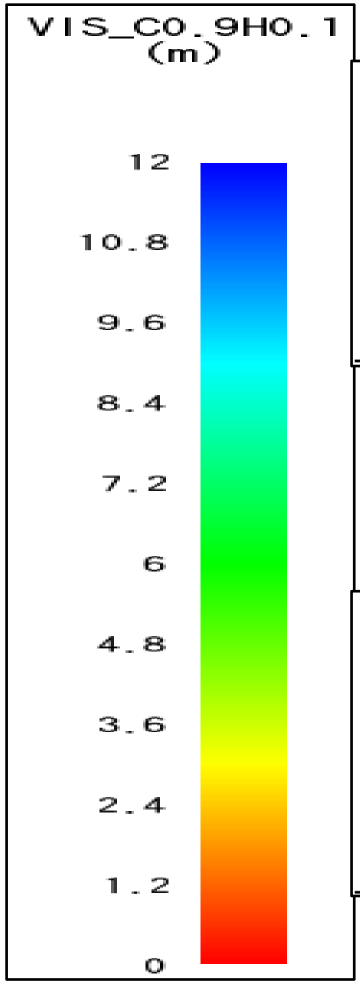
Existing Building

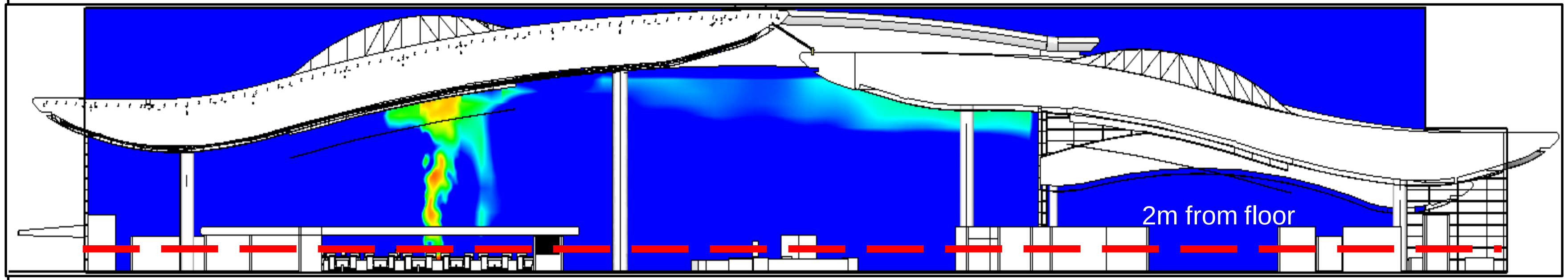
East Processor

05 RESULTS

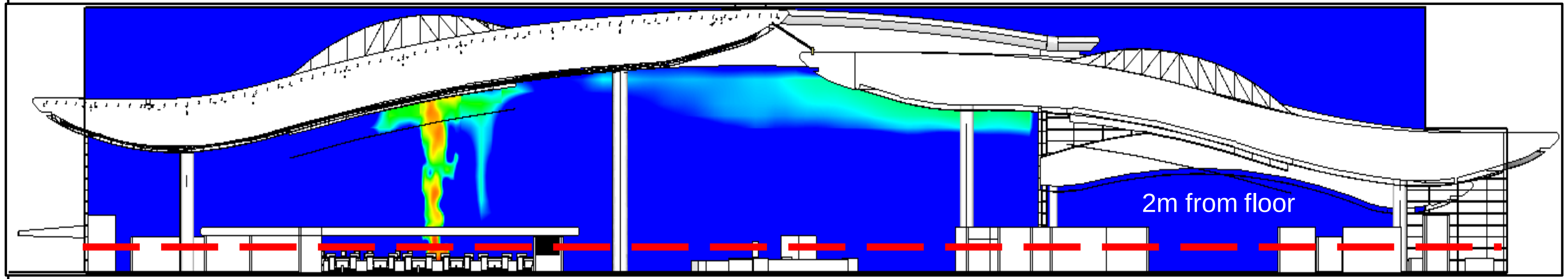
Level F East Processor – Visibility and temperature plots across Check-in counter hall fire.

Smoke visibility plots across fire





Smoke visibility plot @ 600sec

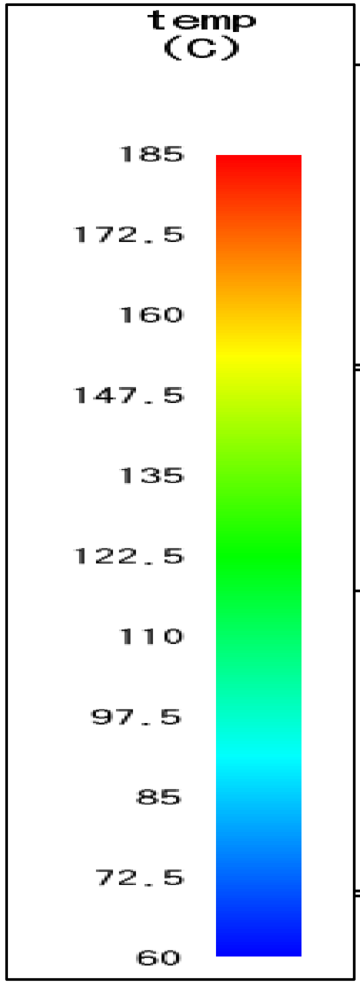


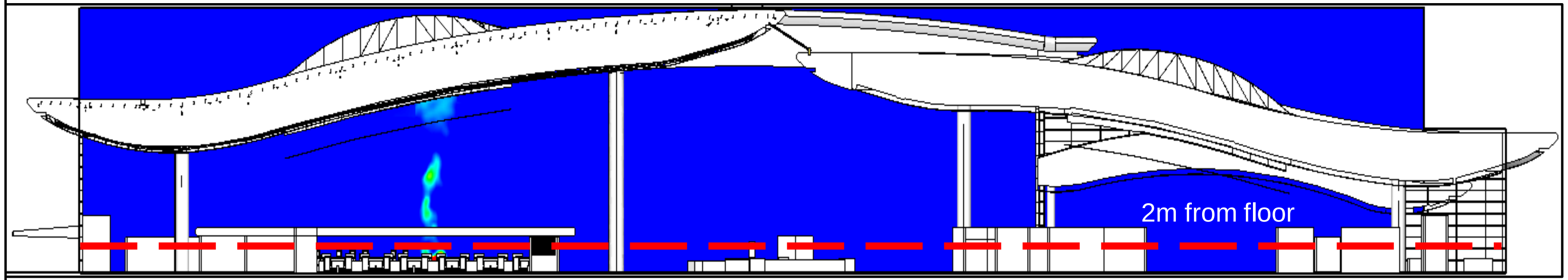
Smoke visibility plot @ 1200sec

05 RESULTS – contd..

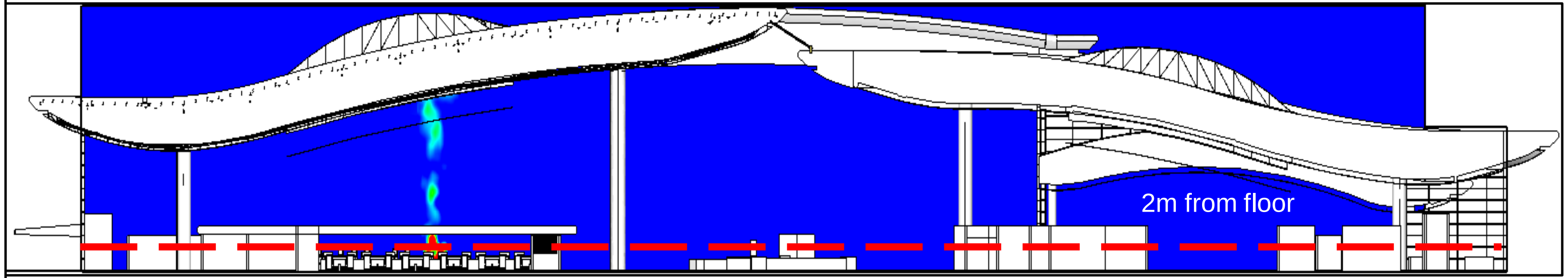
Level F East Processor – Visibility and temperature plots across Check-in counter hall fire

Temperature plots across fire





Temperature plot @ 600sec

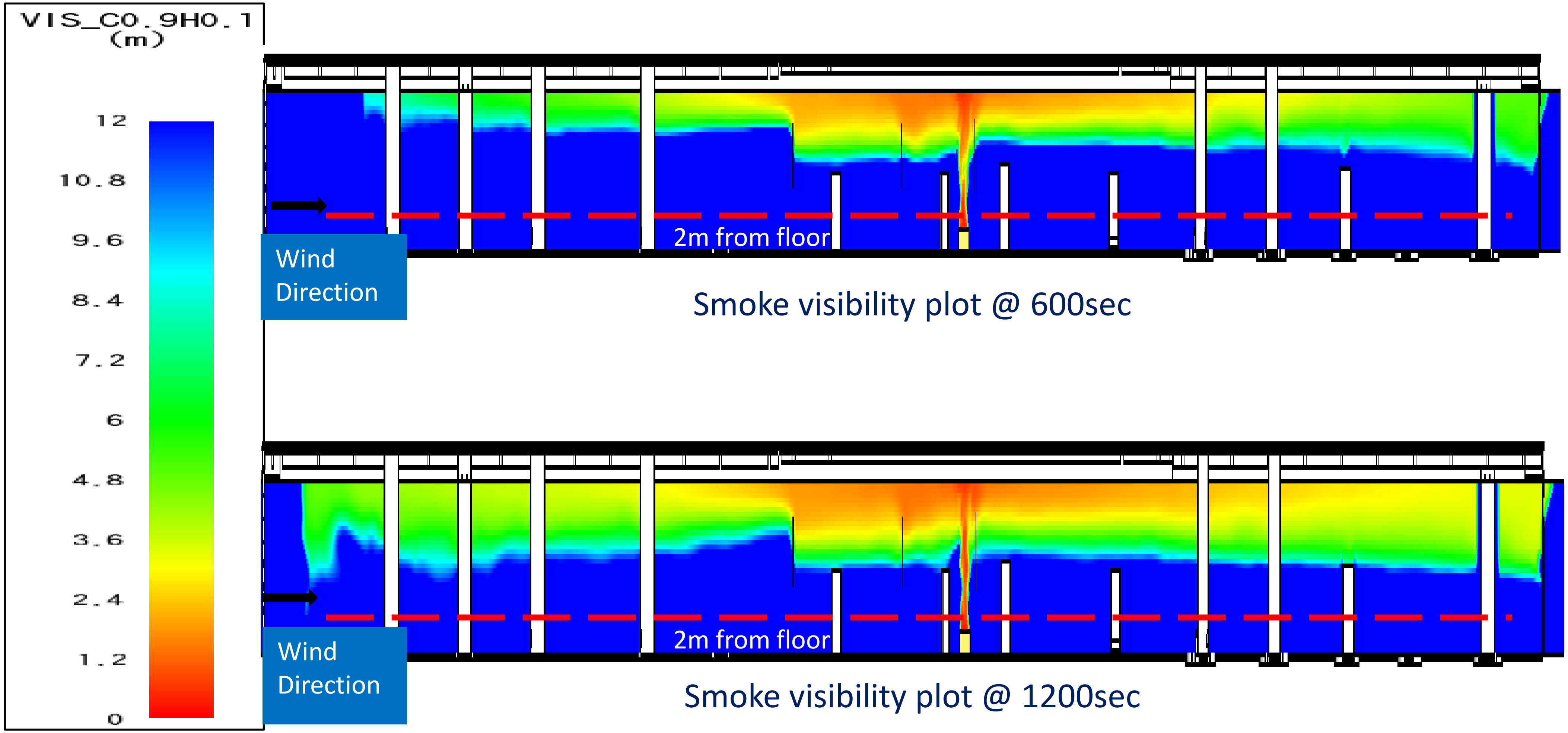


Temperature plot @ 1200sec

05 RESULTS – contd..

Level D Processor with wind effect - Visibility and temperature plots across baggage fire

Smoke visibility plots across fire



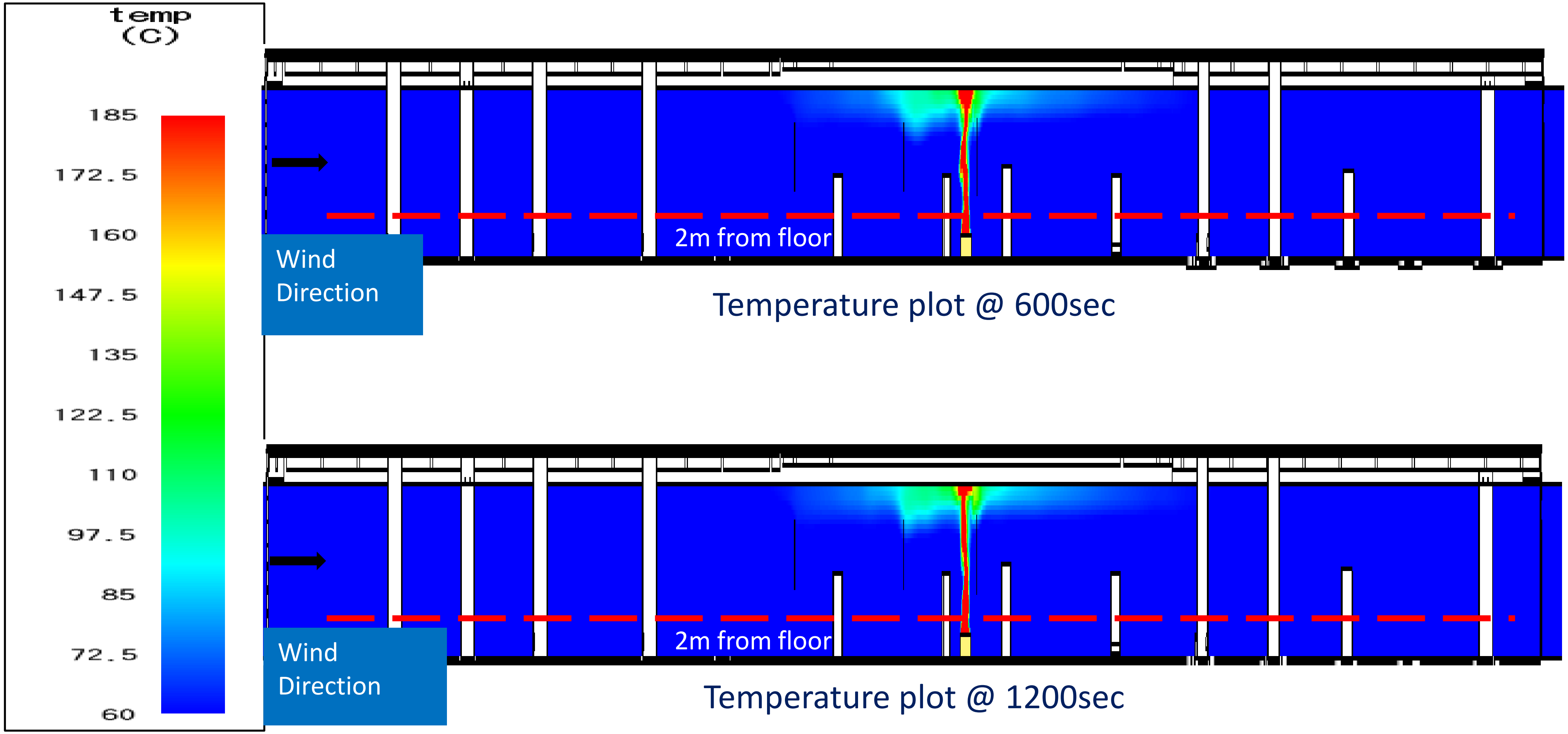
Smoke visibility plot @ 600sec

Smoke visibility plot @ 1200sec

05 RESULTS – contd..

Level D Processor with wind effect - Visibility and temperature plots across baggage fire

Temperature plots across fire



06 CONCLUSIONS

- CFD results demonstrate that smoke spread is limited to the smoke zones of fire origin.
- CFD results show that tenable conditions are maintained for a duration of 20 minutes.
- Smoke spread in the windward direction is affected by wind flow.
- RSET has been calculated to be 3.5 minutes (maximum) for PTB Level D&F. Evaluated ASET from CFD results is 20 minutes, which is more than RSET.
- Based on the CFD results for smoke movement and achieving tenable conditions for life safety, the proposed smoke management system is found to be adequate to meet the design performance requirement stipulated under the fire safety strategy without additional compartmentation.

Thank you

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