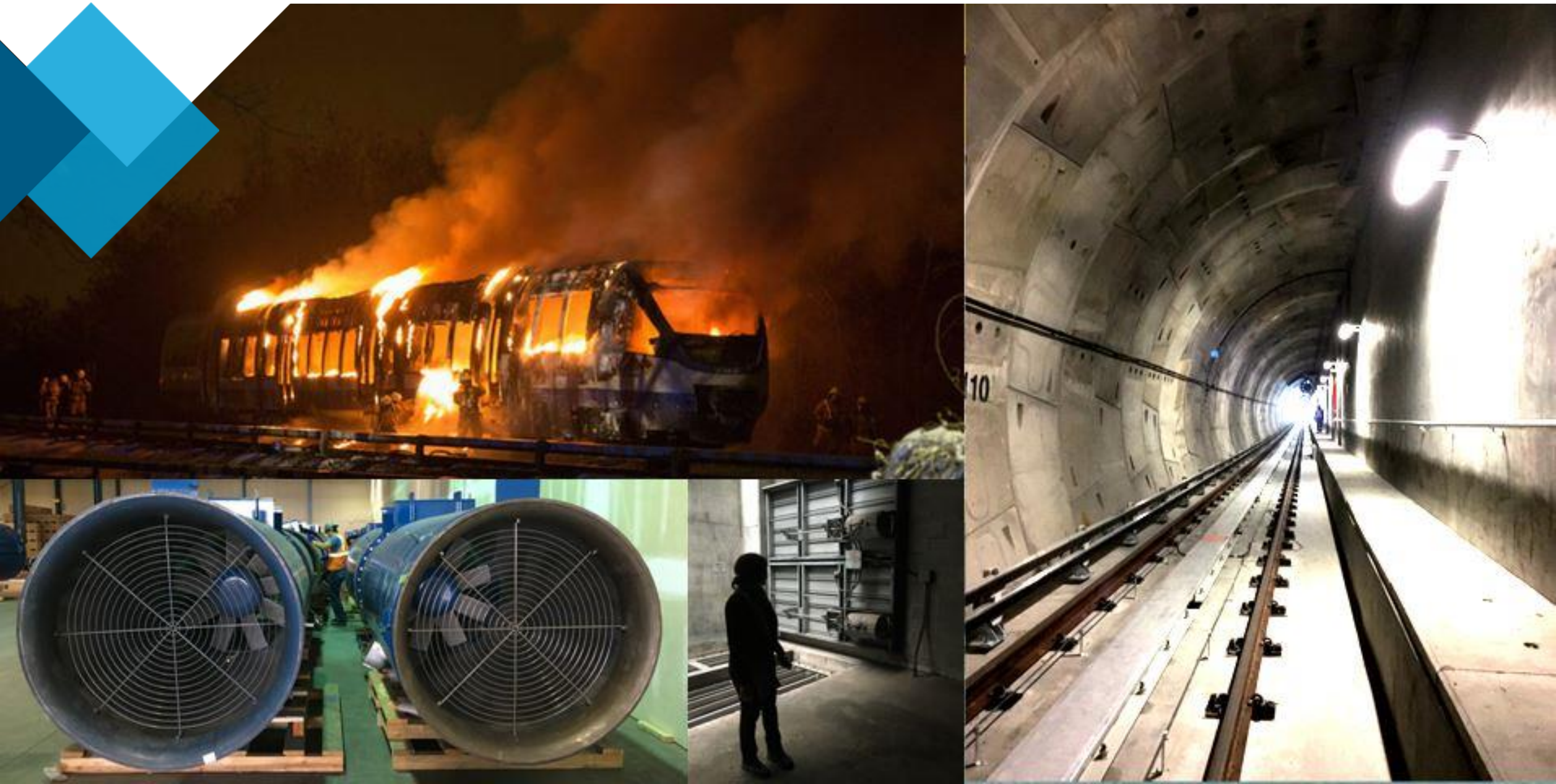
SNC·LAVALIN

Smoke Dispersion Modelling of Exhausted Tunnel Fire Smoke in Urban Areas

FEMTC 2016

Nov 16-18 2016



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Vancouver, Canada
Tunnel Ventilation Engineer

Agenda

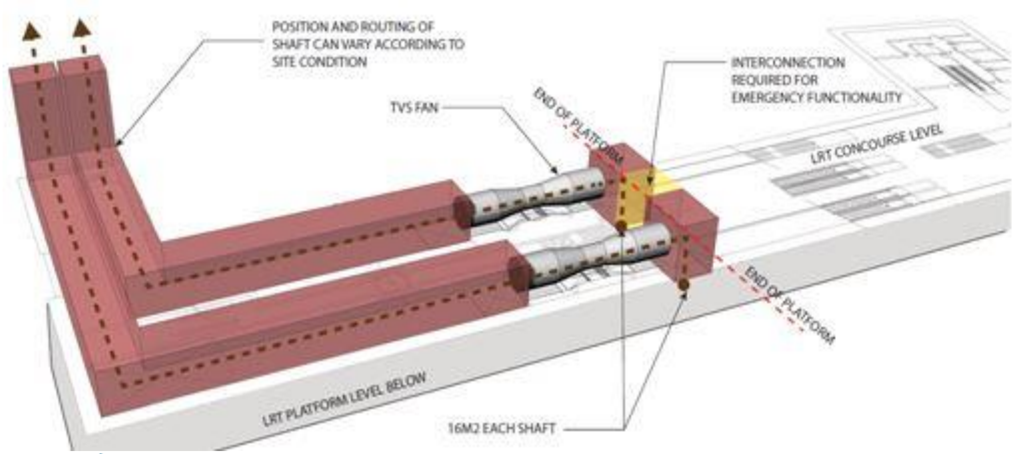
TVS Overview

SDA Modelling Setup

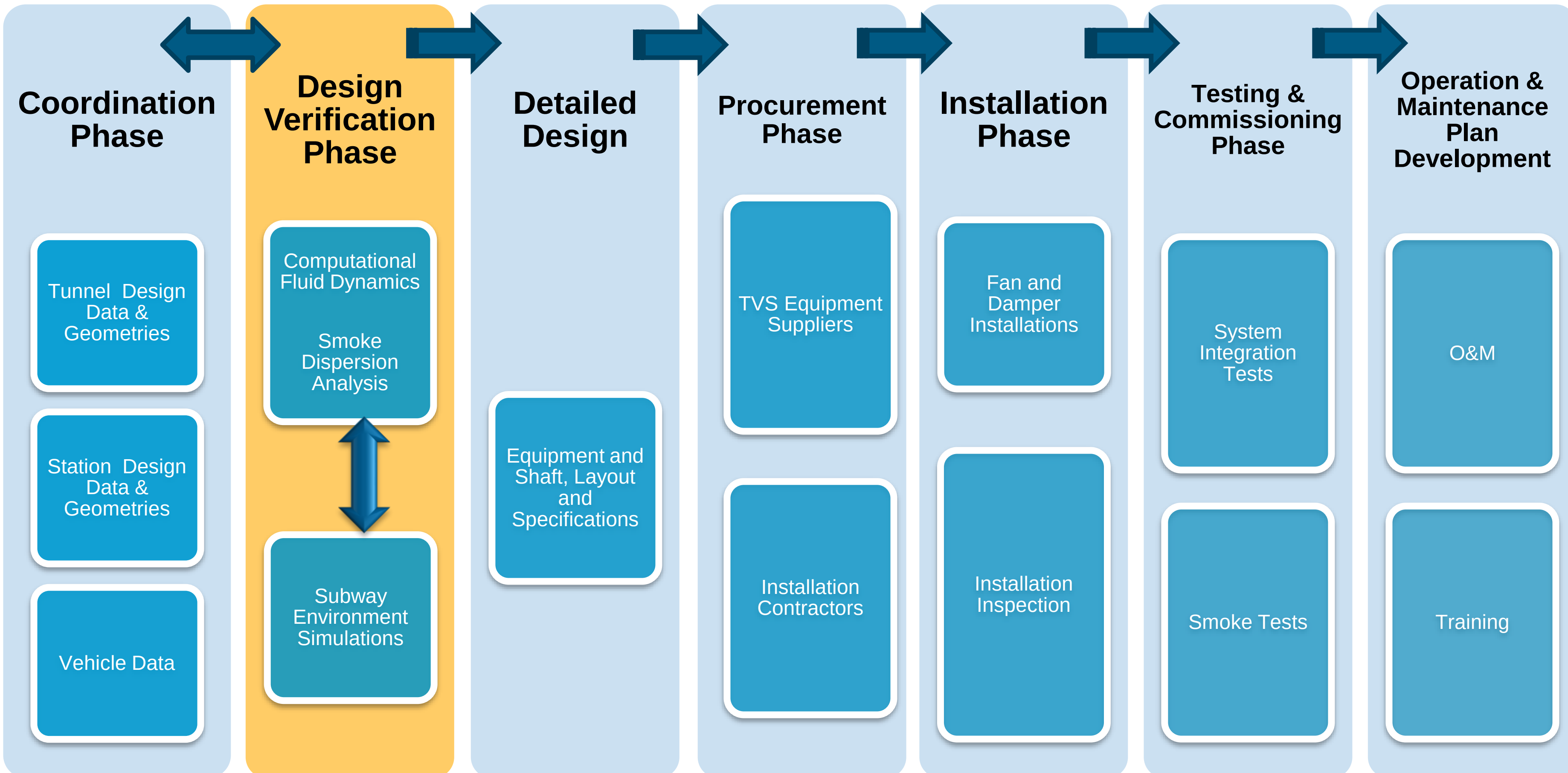
Results

Q&A

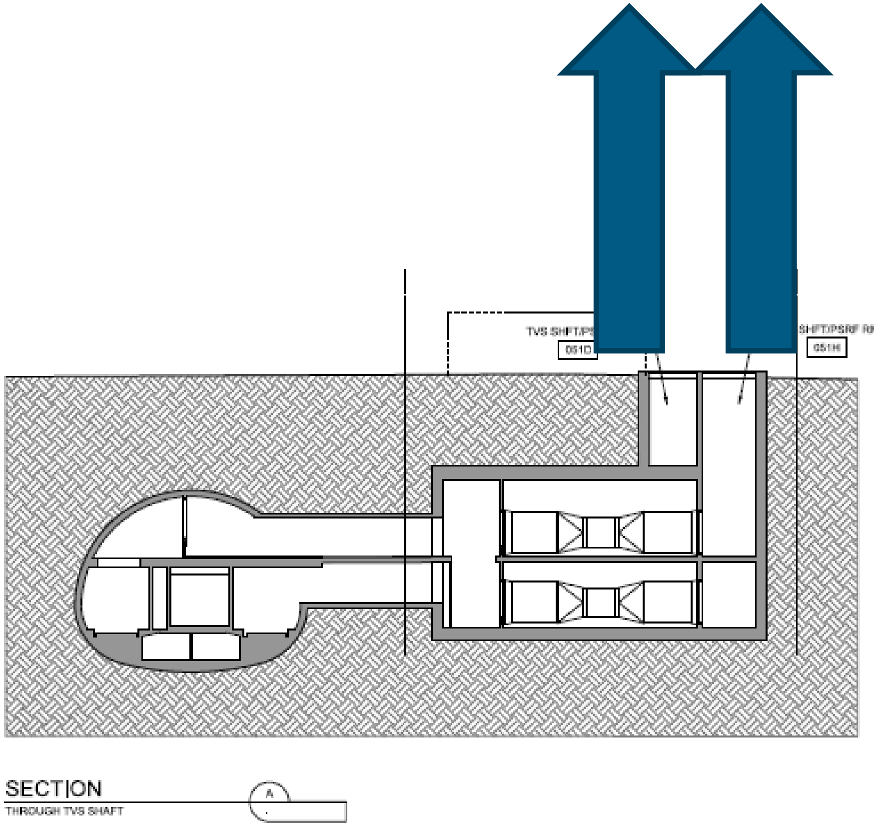
TVS – What is it?



TVS – Comprehensive Approach



TVS Cross Section and Street Grating



TVS Installation

TVS: Why is it required?

Moscow Metro Fire,

June 2013 – 4,500 evacuated, 76 injuries

Cause: Power Line Failure

Daegu, South Korea,

Feb 2003 – 189 deaths, over 100 smoke inhalation injuries,

Cause: Arsonist

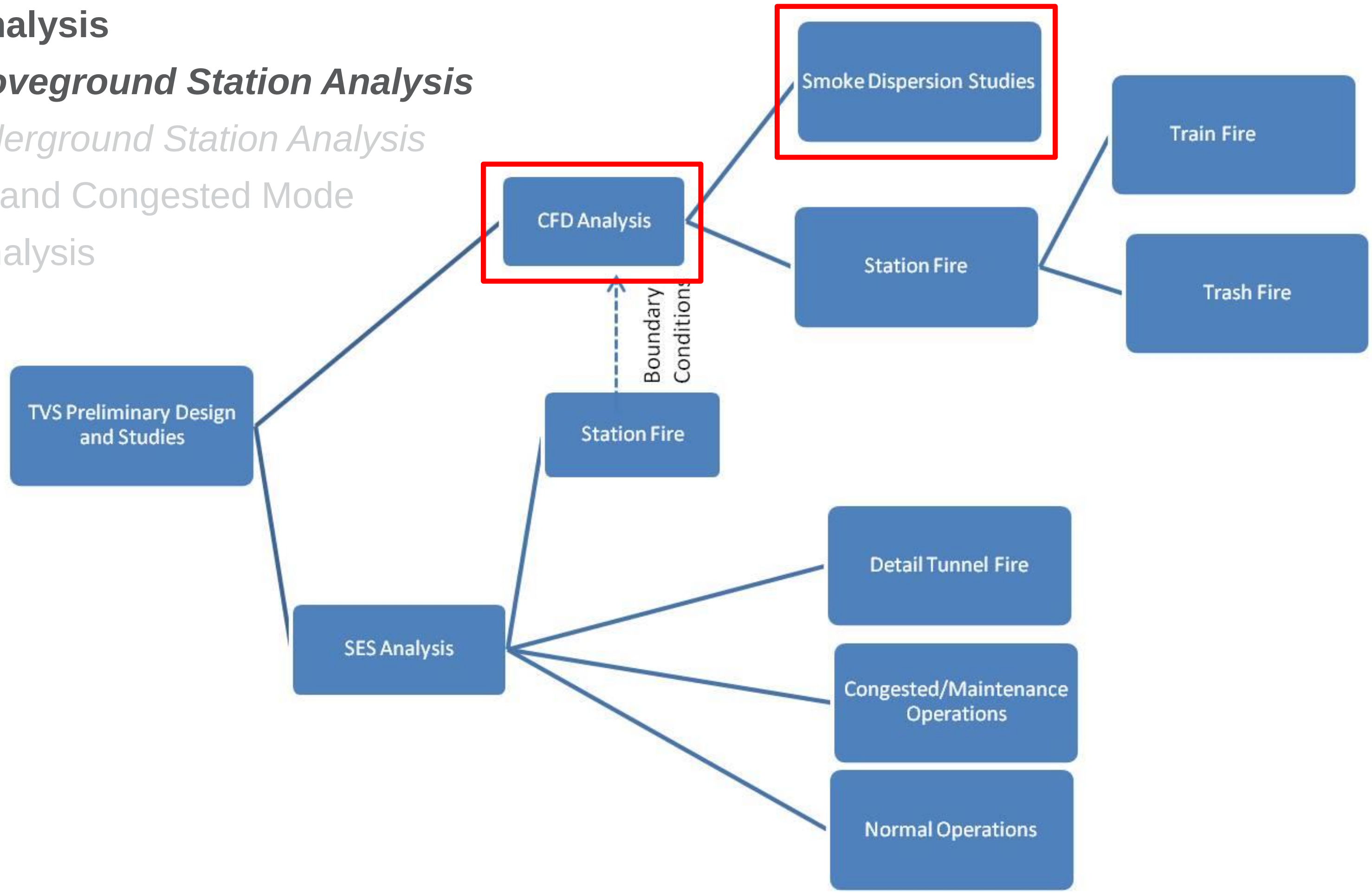
Baku, Azerbaijan,

1995 – 220 passenger deaths, 256 smoke inhalation injuries,

Cause: Electrical Fault

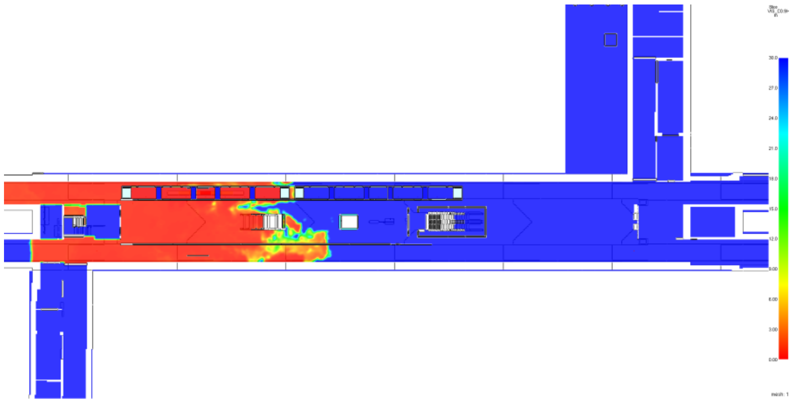
TVS Design – Smoke Dispersion Analysis

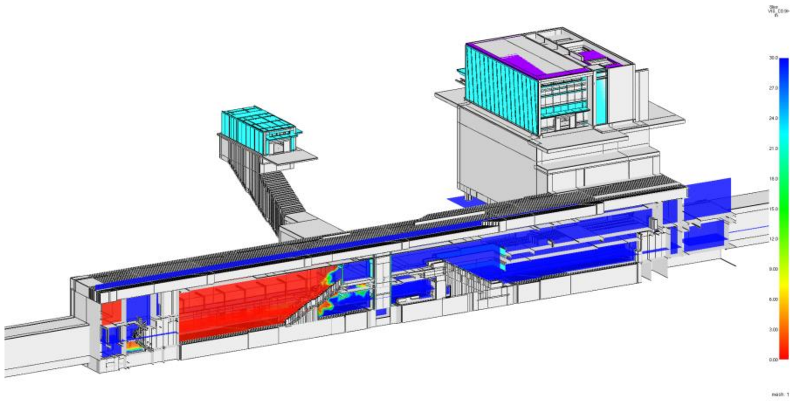
- Emergency Mode
  - **3D Analysis**
    - ***Aboveground Station Analysis***
    - *Underground Station Analysis*
- Normal and Congested Mode
  - 1D Analysis



Typical Example Underground Station CFD

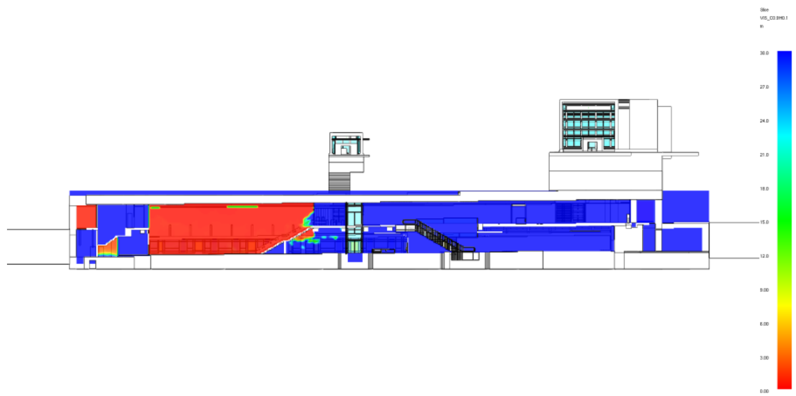
PLATFORM LEVEL





CONCOURSE LEVEL

SECTION VIEW



Smoke Dispersion Effects

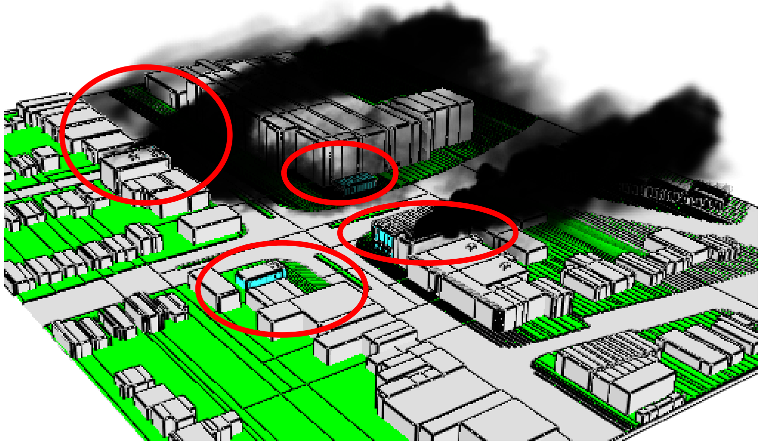
Smoke Dispersion Analysis

FDS6

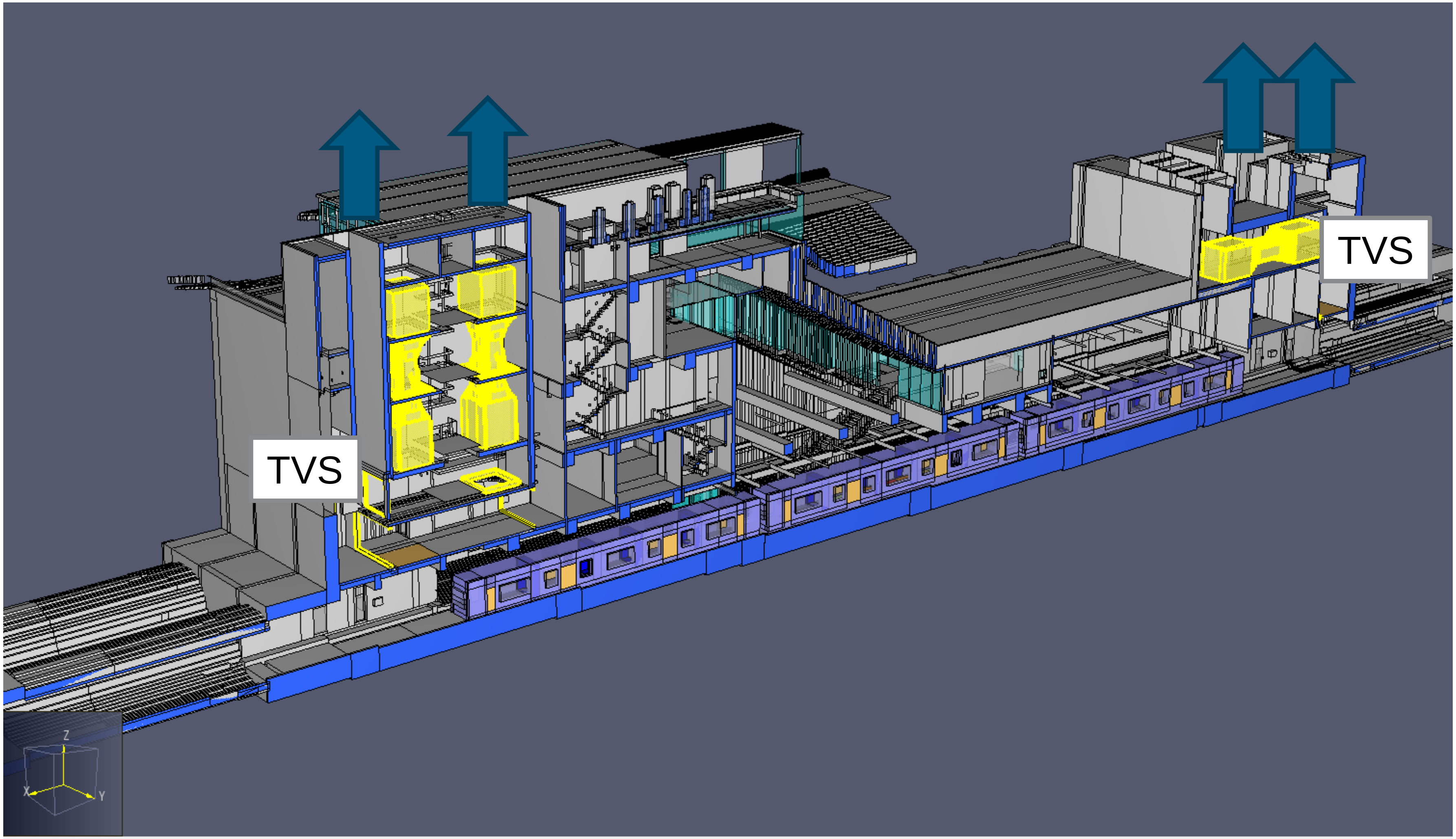
Design Validation

Examine Re-entrainment

Sensitive Receptors & Nearby Buildings



Typical Station Layouts



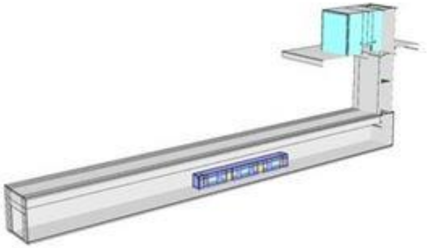
Smoke Temperature Calculation

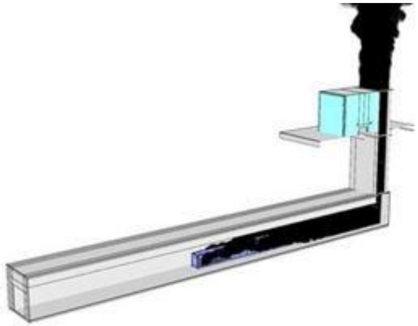
Most Conservative Value

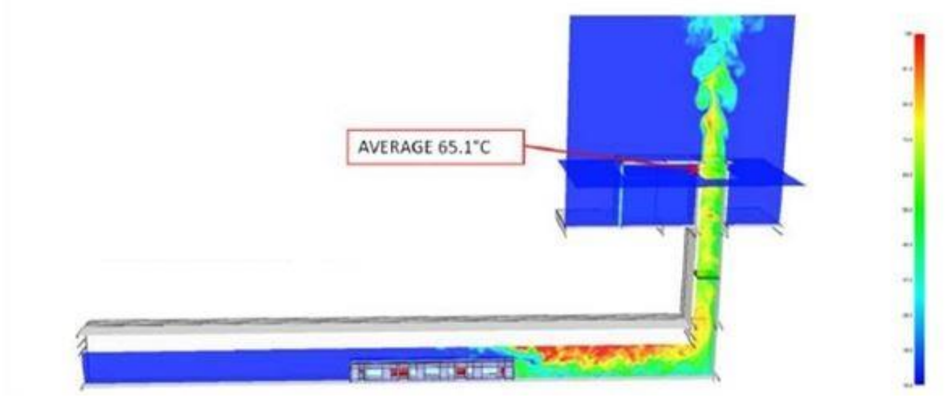
Calculate Coldest Smoke Temperatures

Warmest Ambient Temperatures

Minimal Thermally Driven Effects



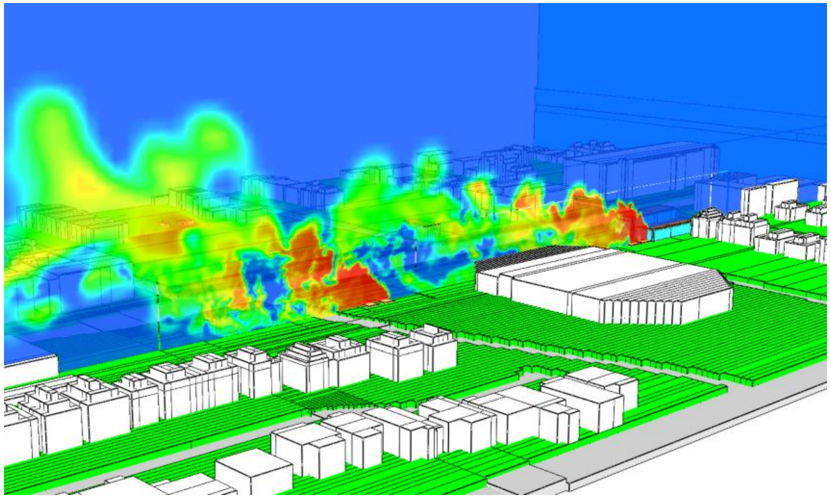




Concentration of Discharge Smoke

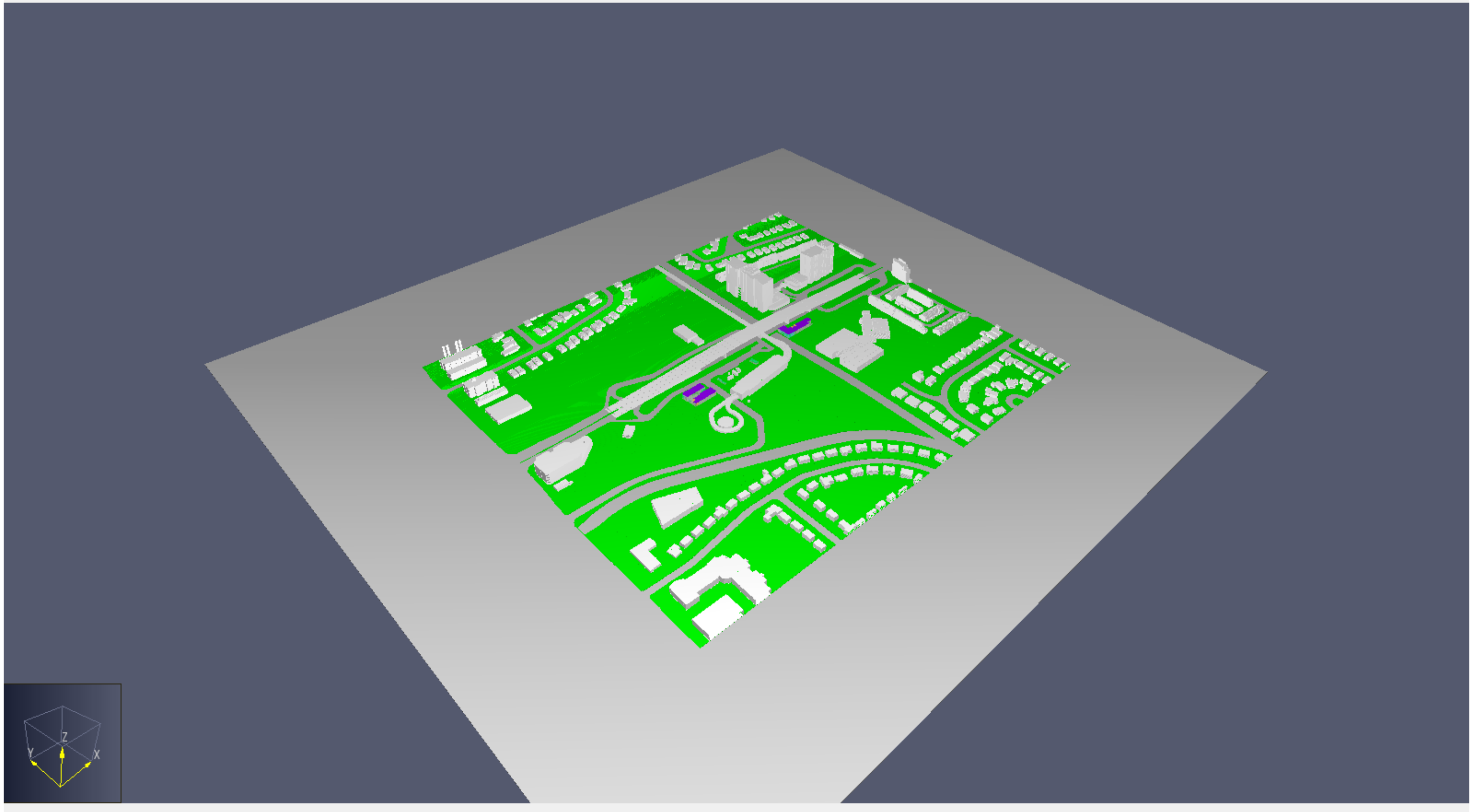
Conservative Estimate: One train car fire is discharged through a pair of vents:

Save Time!



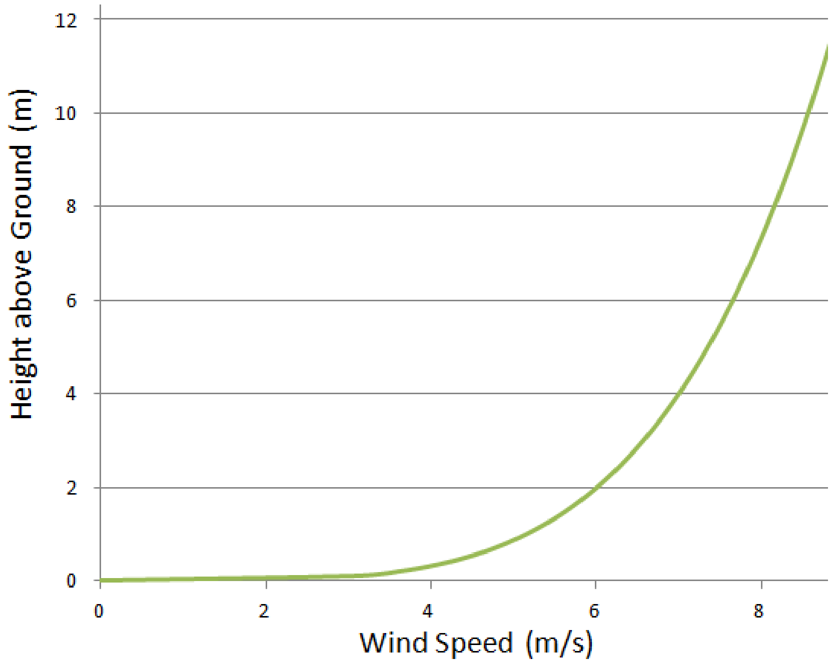
Domain Sizing

(Don’t forget material assignment)

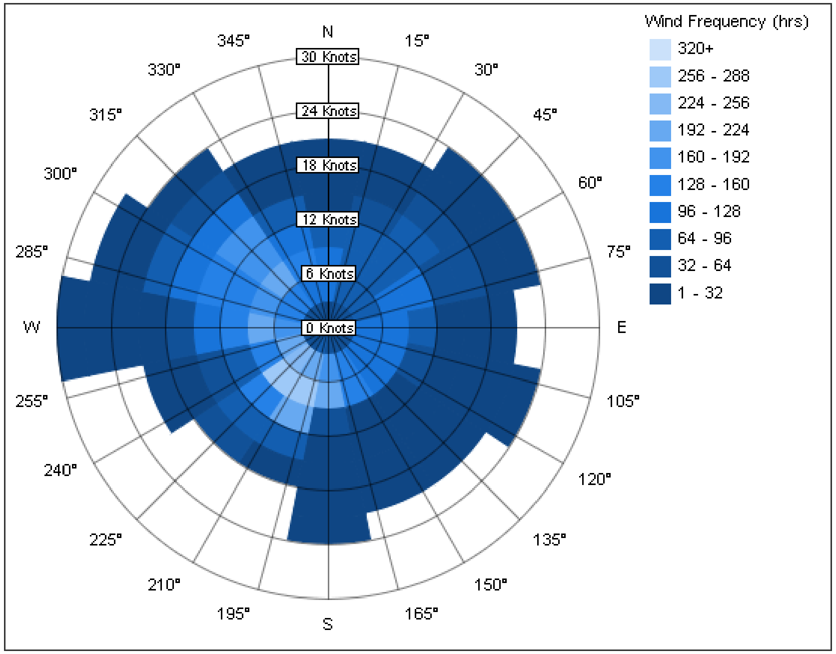


Wind Speed and Direction

ASHRAE Guidelines suggests 1% Wind probability

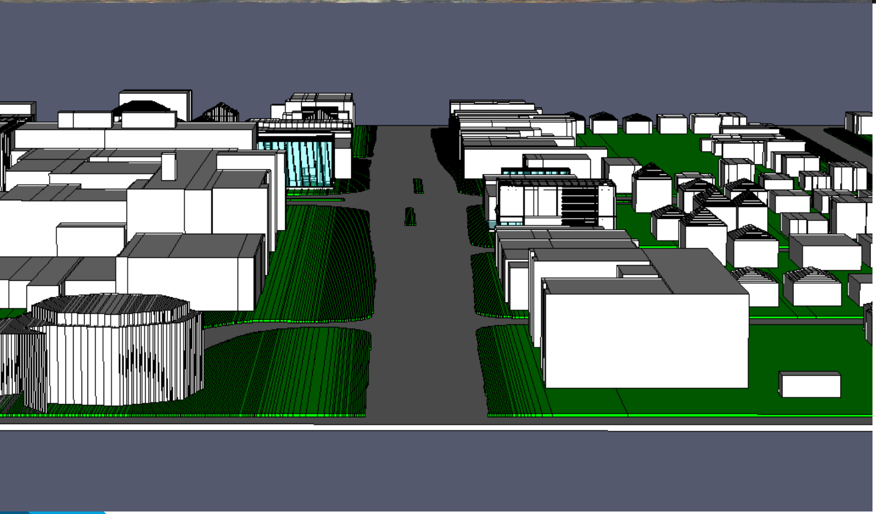


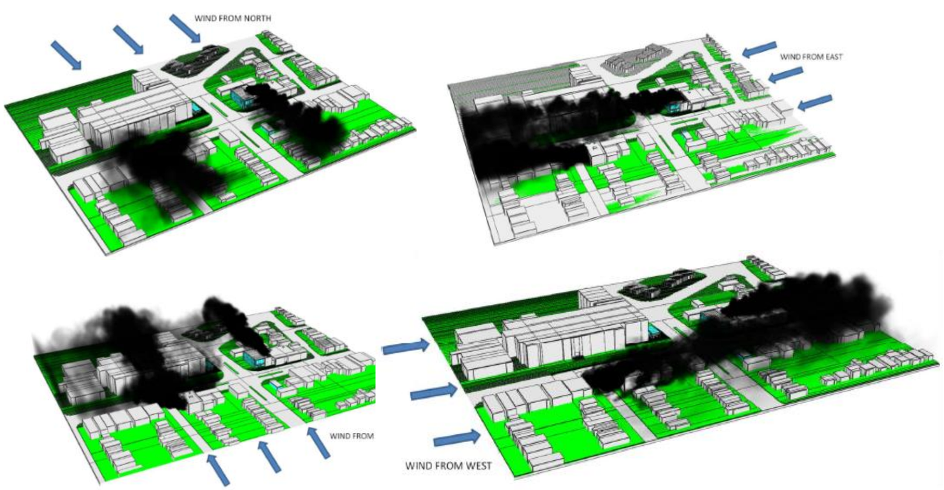
Sample Wind Profile



Sample Wind Rose

Street Canyon Effect

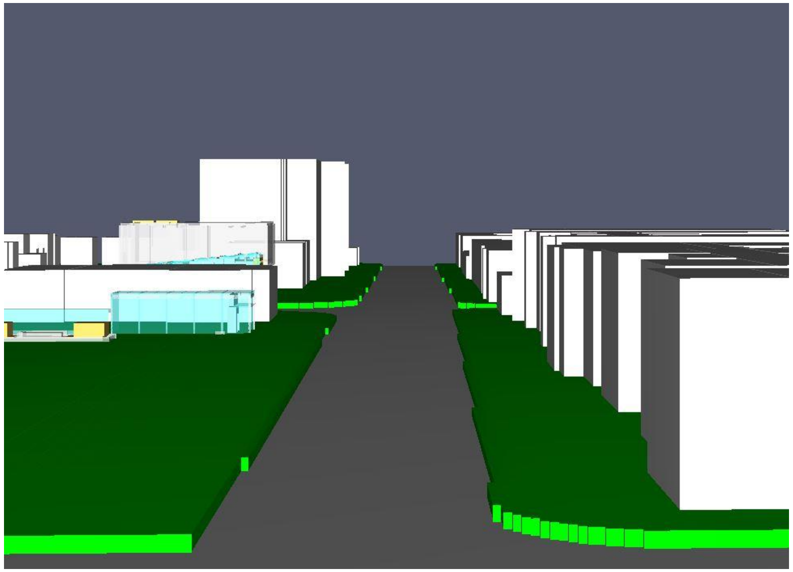




Wind Profile

ASHRAE Handbook of Fundamentals

Conversion of Wind Speeds to Terrain Categories



$$U_H = U_{met} \, (\delta_{met}/H_{met})^{a\text{-}met} \, (H/\delta)^a$$

where

U_{met}	=	airport wind speed (m/s)
δ_{met}	=	boundary layer thickness at the airport [typically 275 m (900 ft)]
$a\text{-}met$	=	boundary layer power law exponent (typically 0.14)
H_{met}	=	anemometer height [typically 10 m (33 ft)]
H	=	building height (m)
a	=	boundary layer power law exponent at the site (typically suburban = 0.22, urban = 0.33)
δ	=	boundary layer thickness at site [typically 365 m (1200 ft) suburban, 460 m (1500 ft) urban].

Wind Boundary Conditions and Domain Size

Sensitivity Test

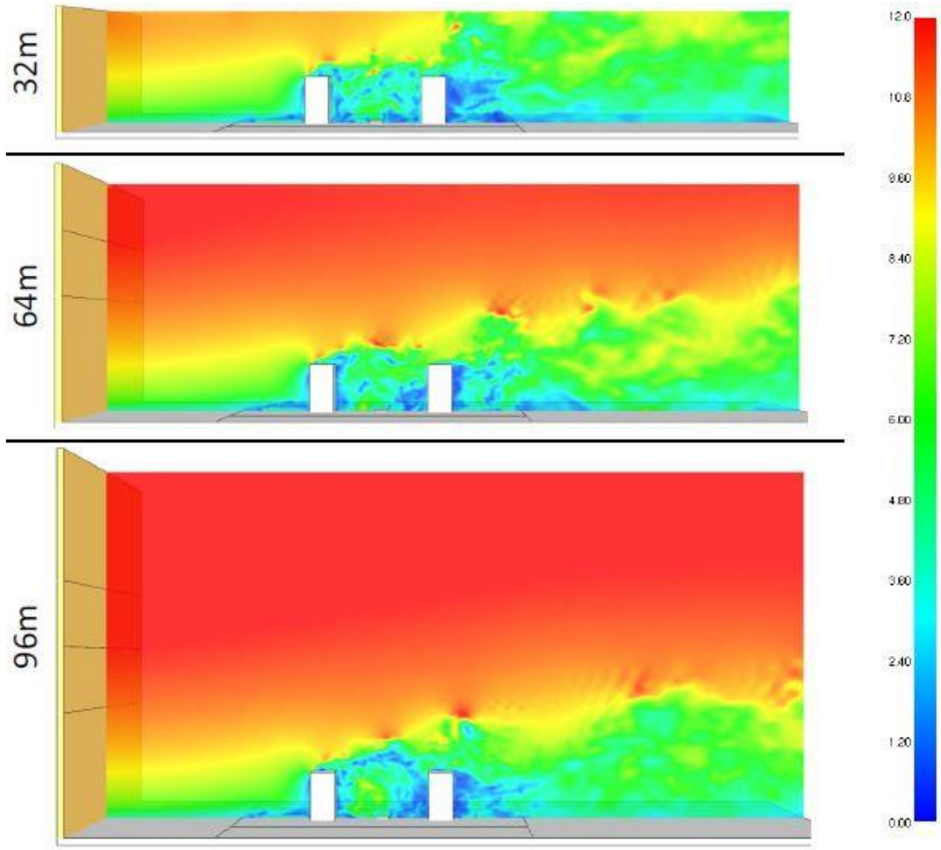
Domain sizing guidelines

Min 5H Height, 5H Leading, 15H Trailing

Ceiling and Sides

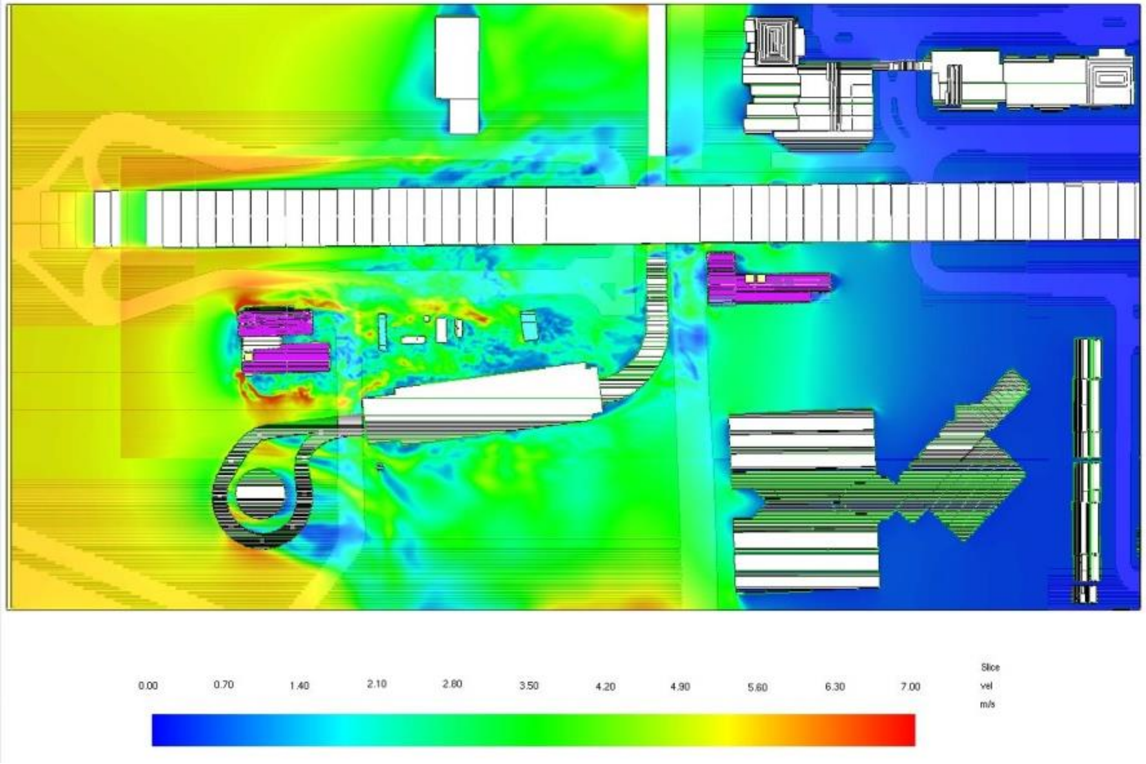
Turbulence Models

LES vs RANS vs DNS

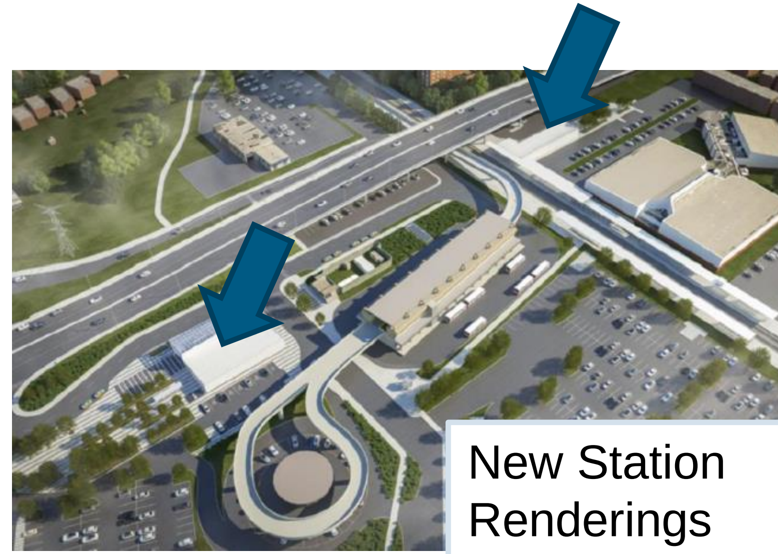


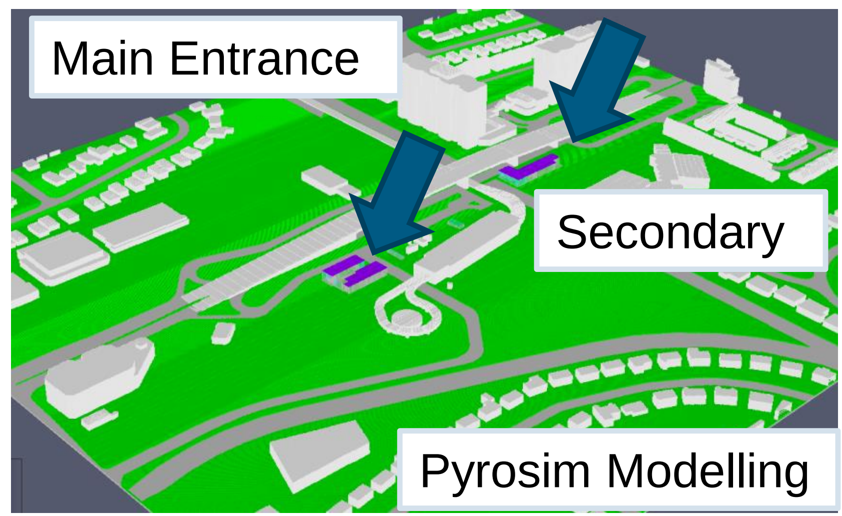
Run Time

Fully Developed Wind

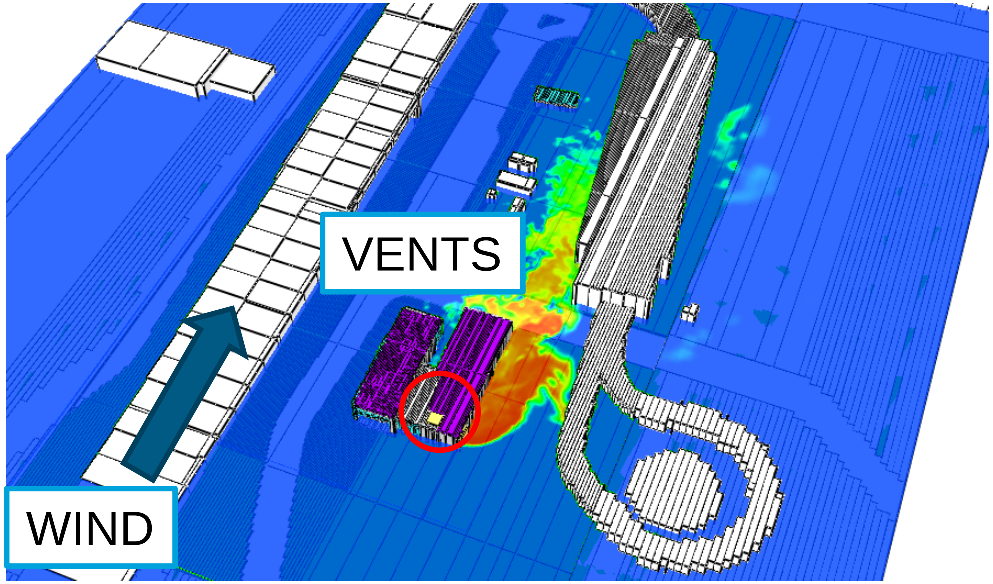


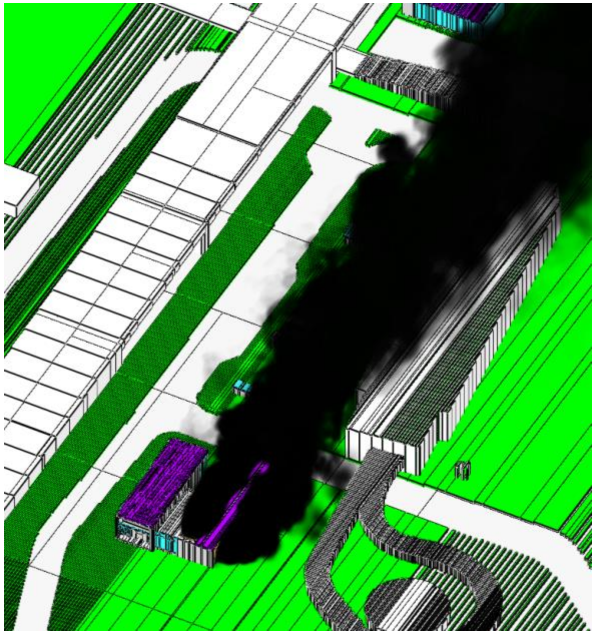
Measurement and Visualization





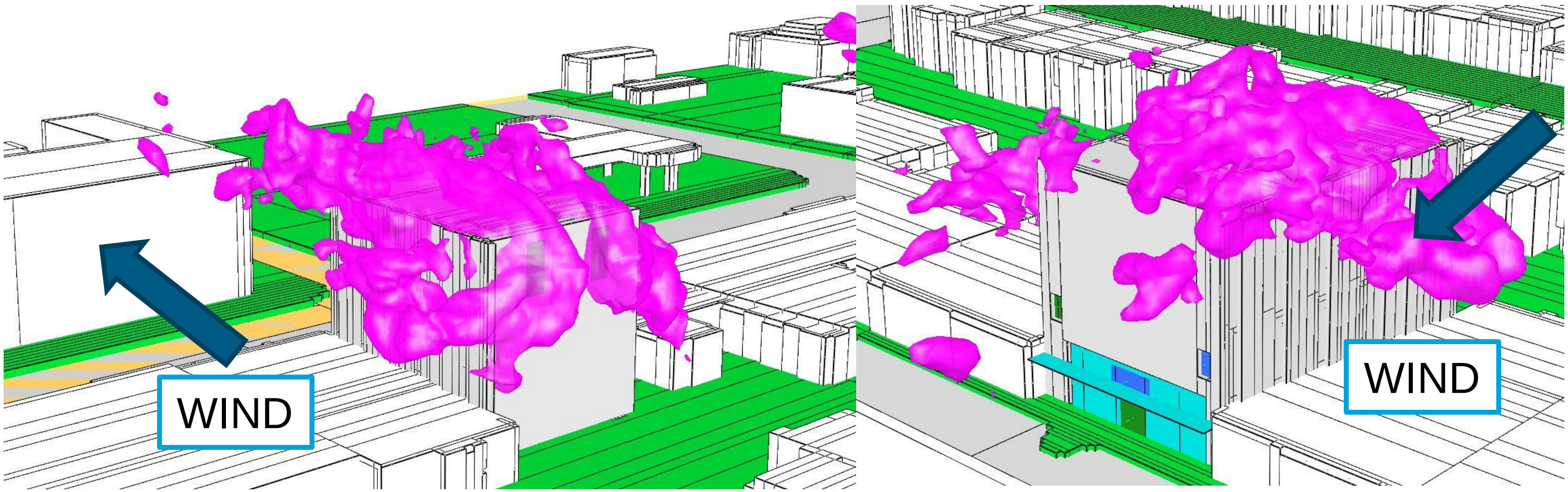
Results Reporting





2.0m Visibility slice above Grade

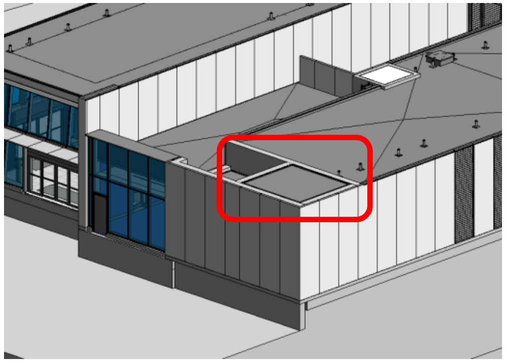
Measurement and Visualization



Isosurfaces: Great for Clients!

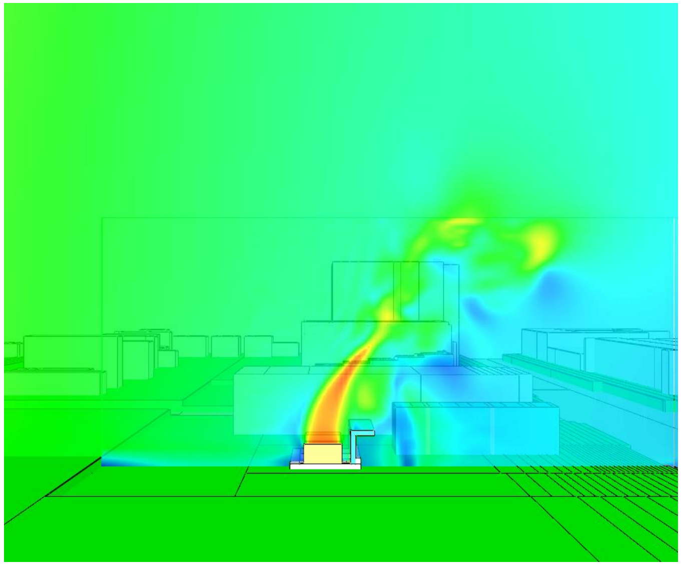
Risk Mitigation

Vent Relocations / Height Changes



Louver Selection

Ejection Velocity



Adjacent buildings notified / HVAC Updates

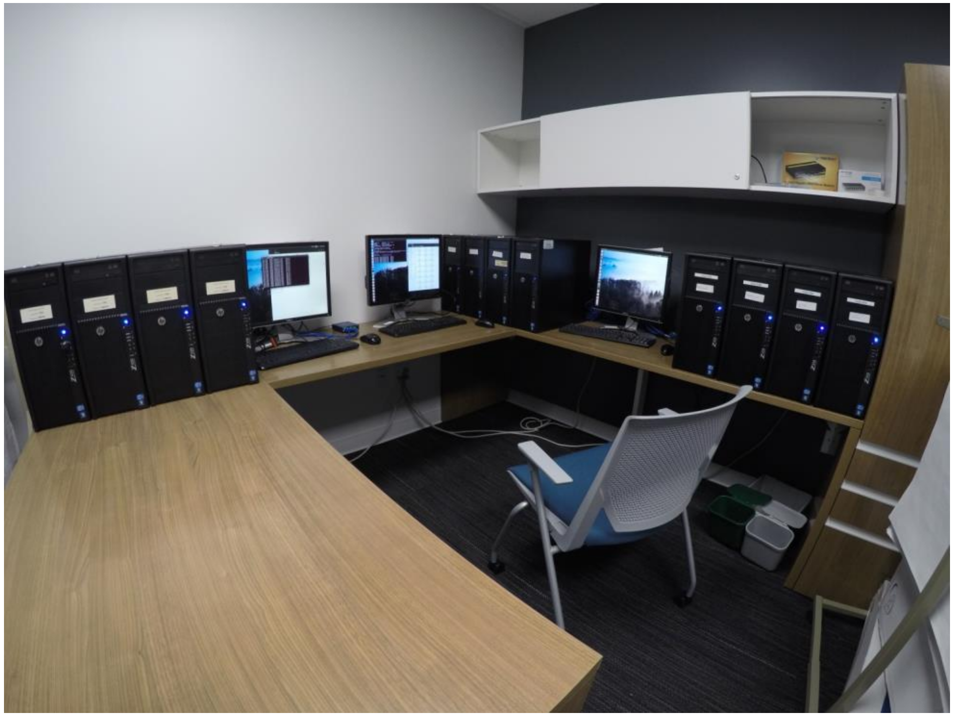
Outlook and Future

Foliage Trees and Vehicle Effects

Mesh resolutions with computing power

Keep updated on large scale validation of Wind Boundary Conditions in FDS

Future applications



Thanks for your attention!

Questions?