

Evacuation Simulation Modeling for a Deep Underground Subway Station

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Outline

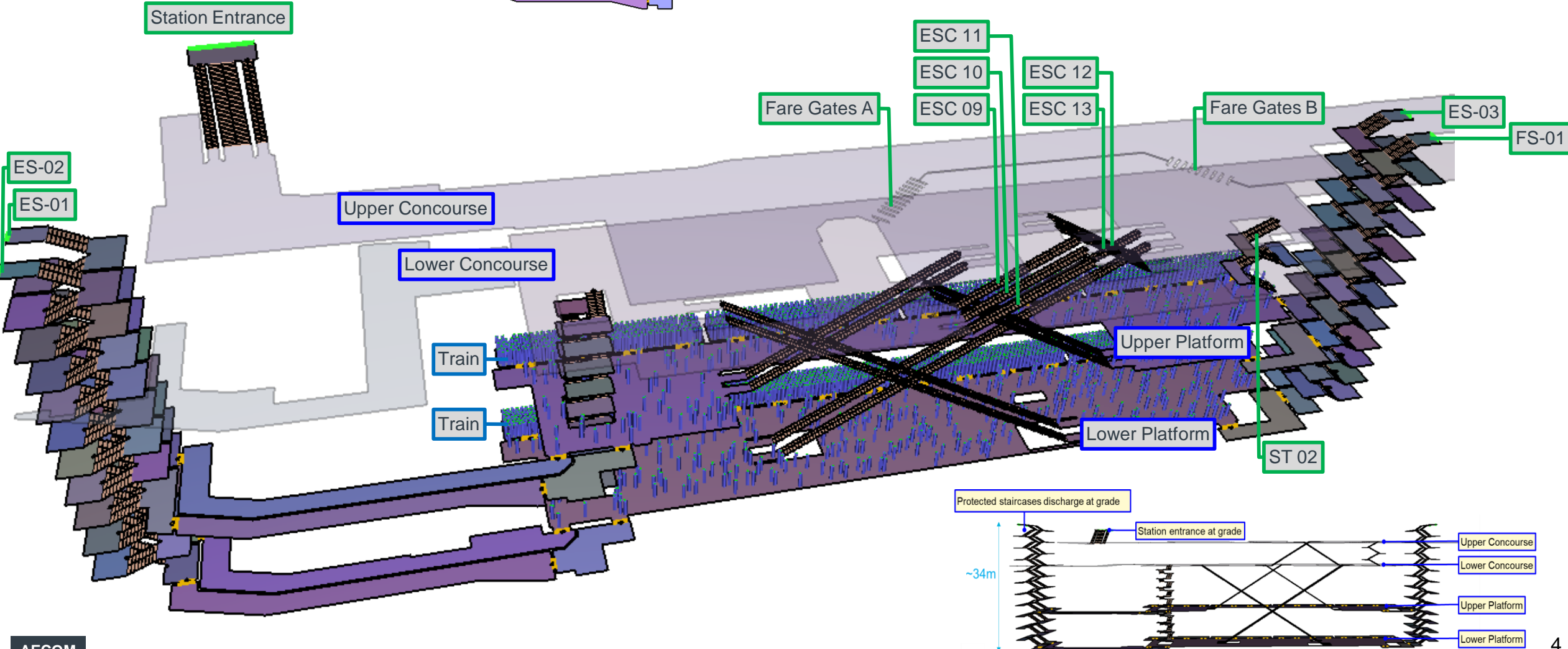
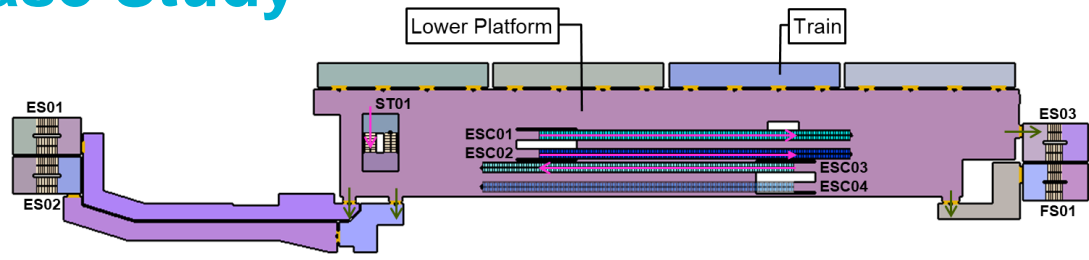
- Introduction / Objective
- Subway Station for Case Study
- Model Inputs / Assumptions
- Case Studies
- Results
- Conclusion / Future Research

Introduction / Objective

- Trend of increasing urbanization, majority in ASEAN adding to existing problem of congestion
- Increased development of underground subway systems in South East Asia countries
- NFPA 130 typically adopted as reference for fire safety design/requirements
- NFPA 130 Evacuation requirements: -
 - Evacuate platform in 4 minutes
 - Reach point of safety (POS) in 6 minutes
- Dynamic evacuation modeling (Pathfinder) expected to yield different results compared to static evacuation calculations
- Examine cost factor for room queue time / location of final exits and their impact on exit choice by occupants / evacuation time of platform

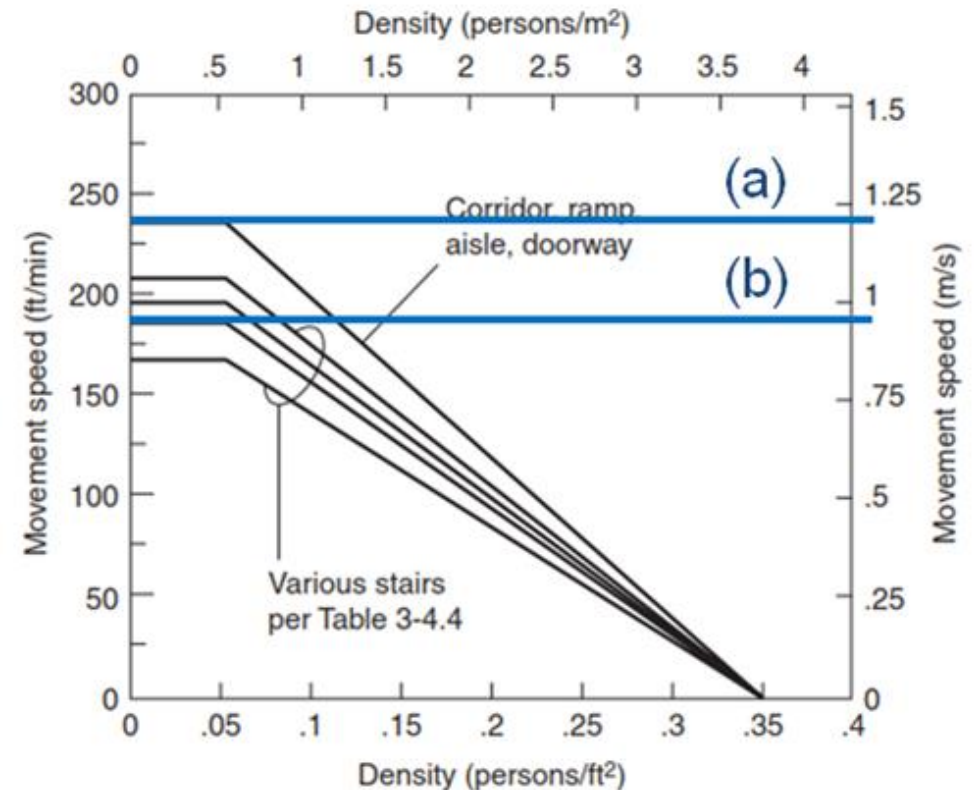
Subway Station for Case Study

- 5 Underground Levels (B1 to B5)
- ~ 34m deep



Model Inputs / Assumptions

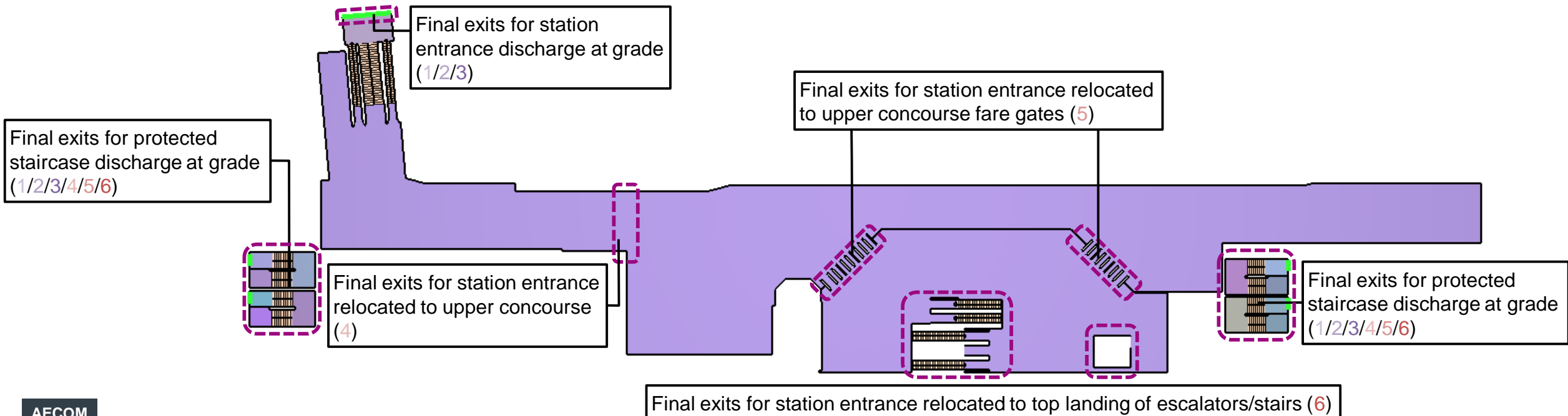
- 2369 persons (worst case passenger loads – NFPA130 principles)
- Maximum unimpeded walking speed: -
 - (a) Flat surface = 1.19 m/s
 - (b) Stairs / Escalators (stationary) = 0.92 m/s
- Moving escalator speed = 0.75 m/s
- Capacities (width) of egress components: -
 - Protected staircase = 2.2 m
 - Escalator = 1.2 m / 1.0 m
 - Open staircase = 1.5 m / 2.5 m
- Occupants walk on moving escalators
- Discounting 1 escalator



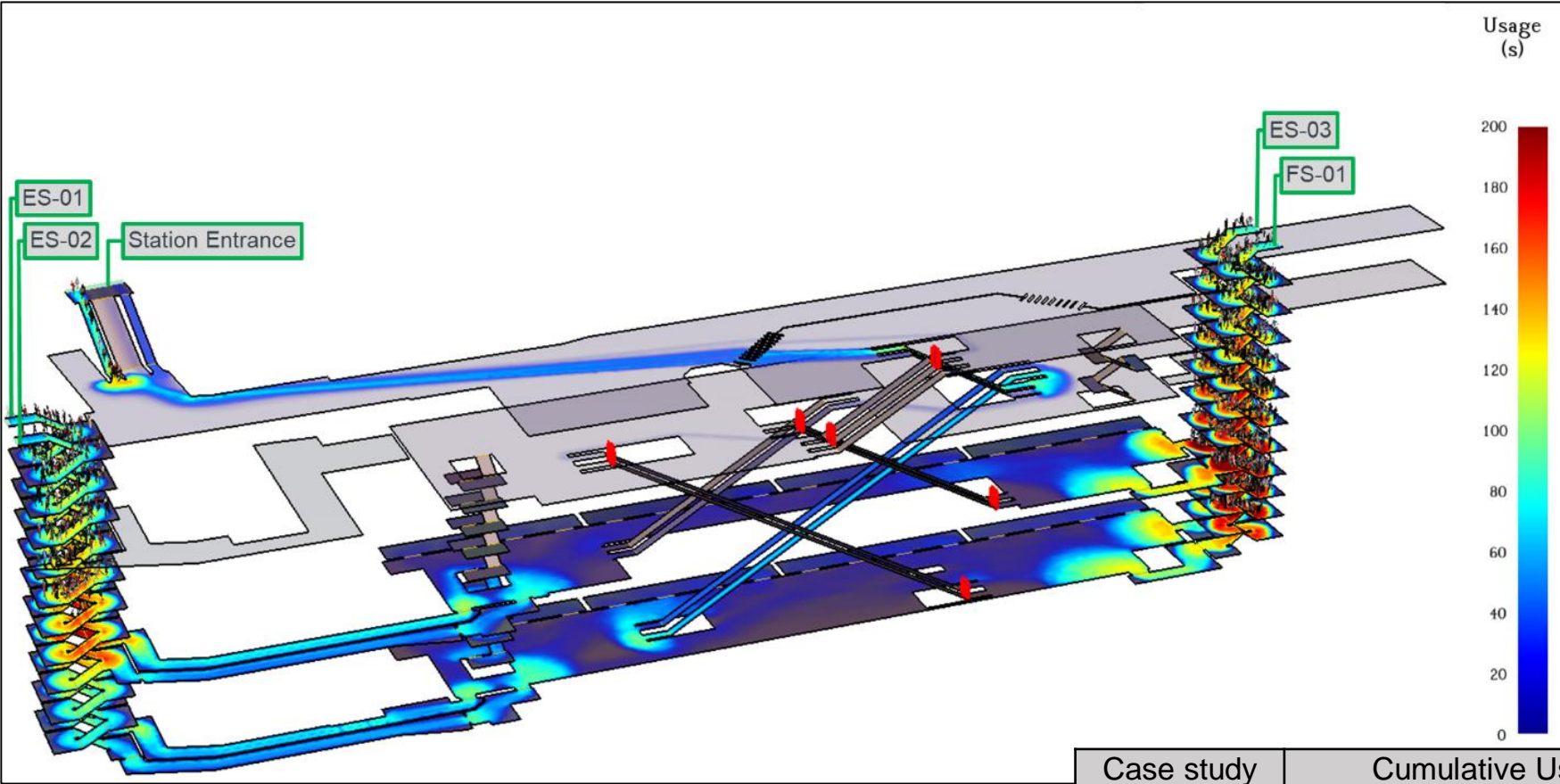
Ref: SFPE Handbook of Fire Protection Engineering, 3rd Edition – Figure 3-14.4 (Nelson & Mowrer)

Case Studies

Case study	Cost factor (room queue time)	Location of evacuation model final exits
Case study 1	1	Final exits all located at grade
Case study 2	3	Final exits all located at grade
Case study 3	5	Final exits all located at grade
Case study 4	1	Final exits for protected staircases remain at grade; Exit point at station entrance relocated to upper concourse.
Case study 5	1	Final exits for protected staircases remain at grade; Exit point at station entrance relocated to upper concourse fare gates A and B.
Case study 6	1	Final exits for protected staircases remain at grade; Exit point at station entrance relocated to top landing of escalators and open stairs at upper concourse.



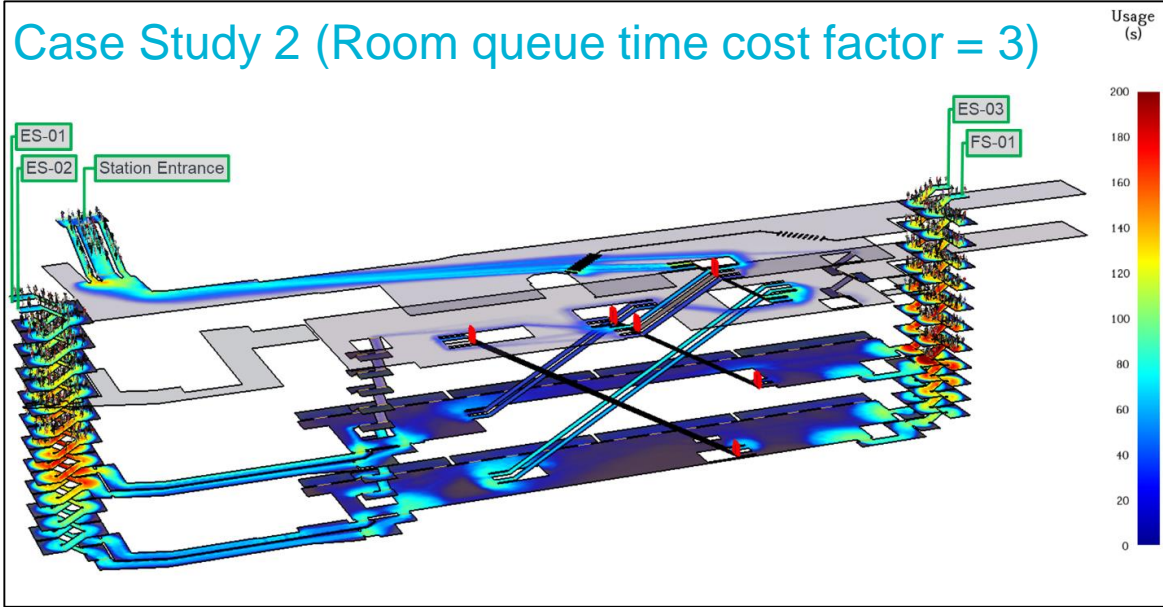
Results – Case Study 1 (Base Case)



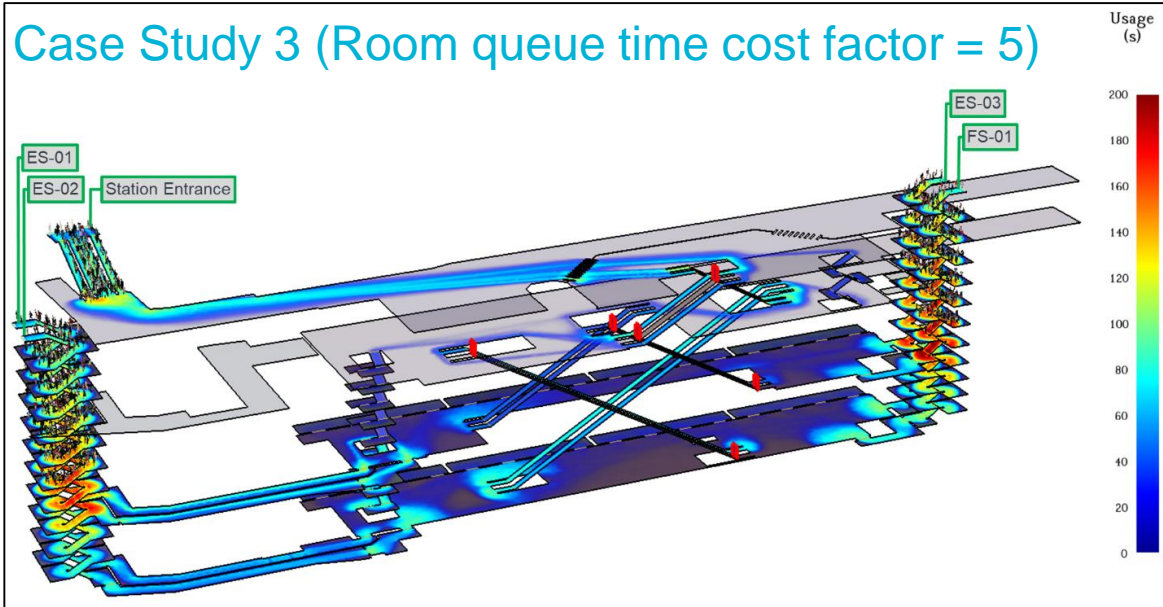
Case study	Cumulative Usage of Exits		Platform Clearance Time	
	Station Entrance	Escape Staircases	Lower	Upper
Case study 1	10.6%	89.4%	3min:12s	3min:23s
Case study 2				
Case study 3				
Case study 4				
Case study 5				
Case study 6				

Results – Case Study 2 / 3

Case Study 2 (Room queue time cost factor = 3)

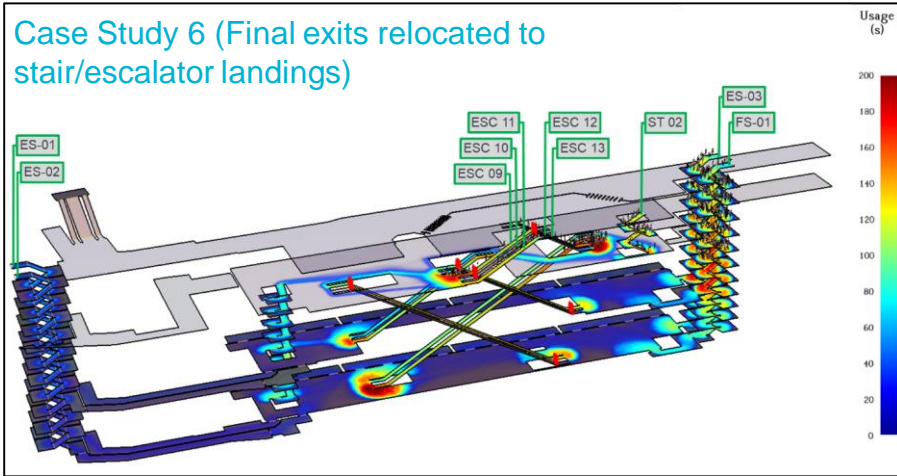
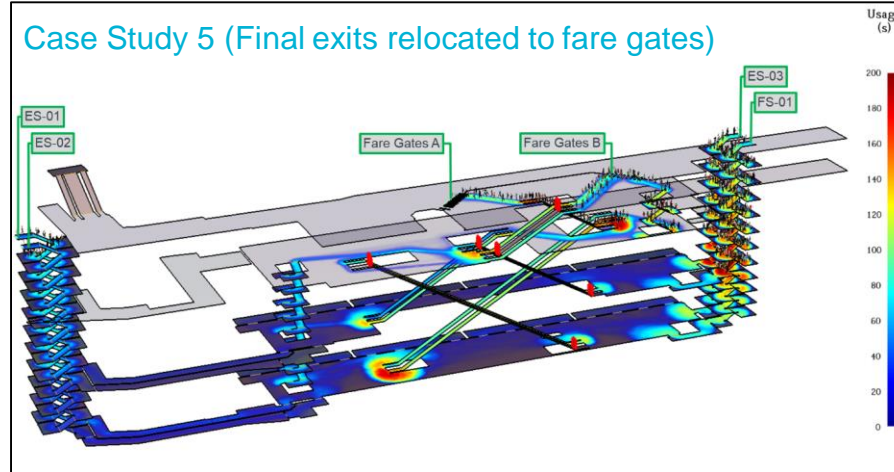
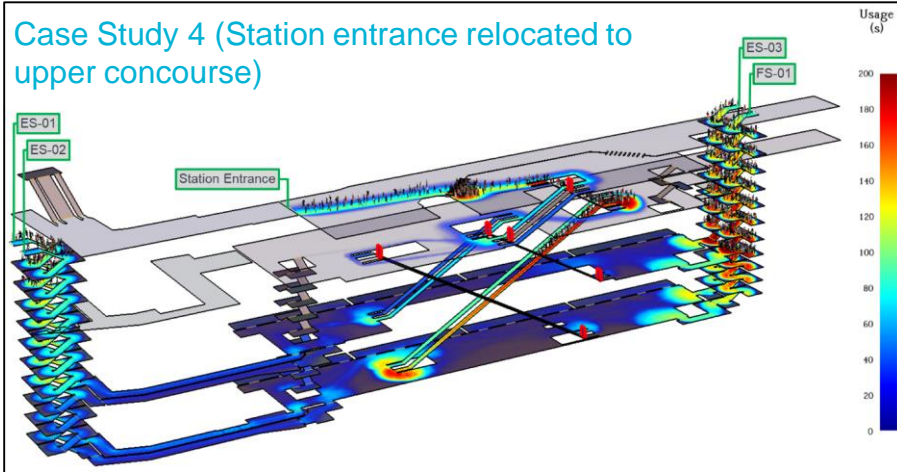


Case Study 3 (Room queue time cost factor = 5)



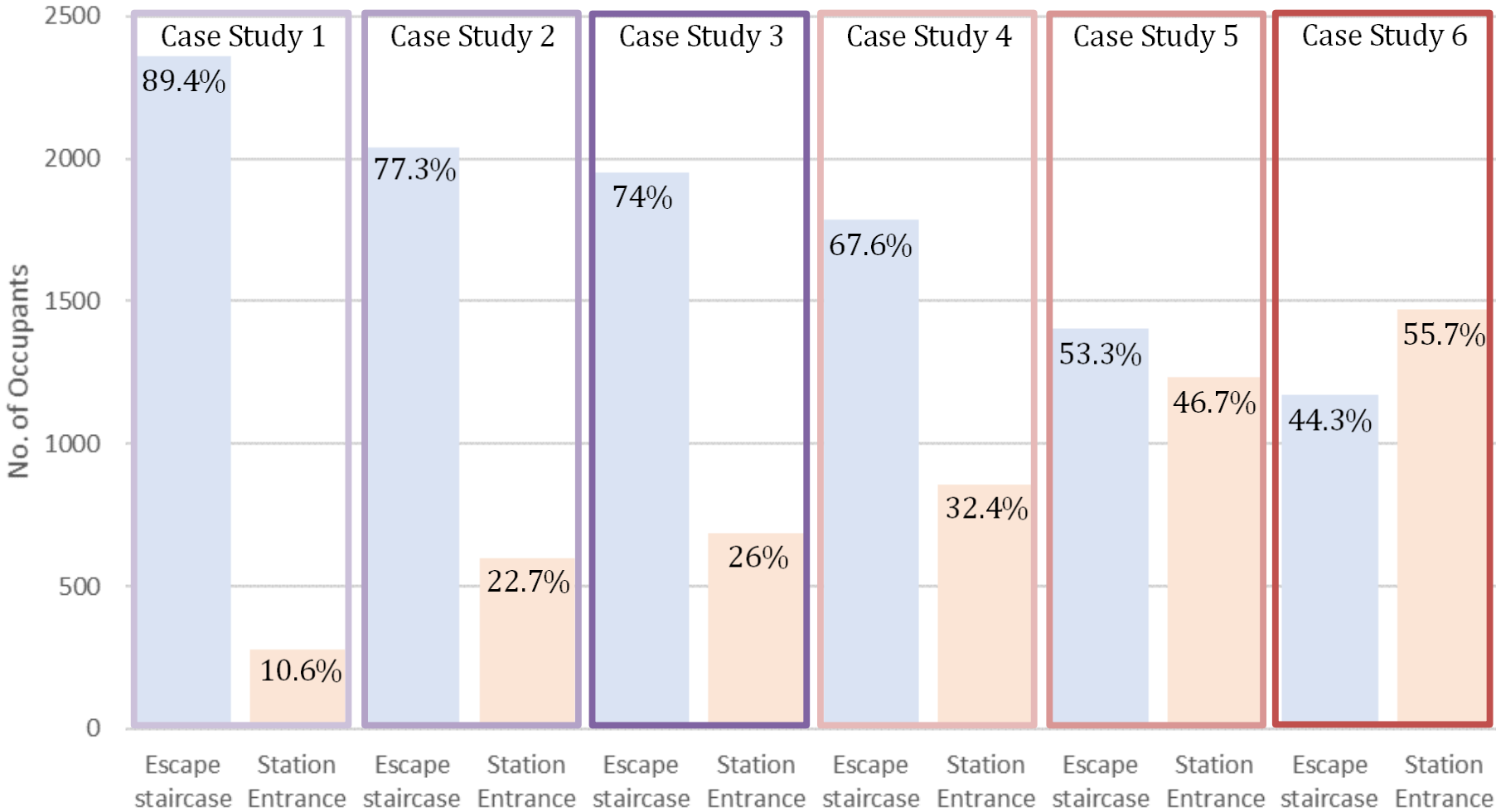
Case study	Cumulative Usage of Exits		Platform Clearance Time	
	Station Entrance	Escape Staircases	Lower	Upper
Case study 1	10.6%	89.4%	3min:12s	3min:23s
Case study 2	22.7%	77.3%	2min:51s	3min:27s
Case study 3	26%	74%	2min:49s	3min:35s
Case study 4				
Case study 5				
Case study 6				

Results – Case Study 4 / 5 / 6

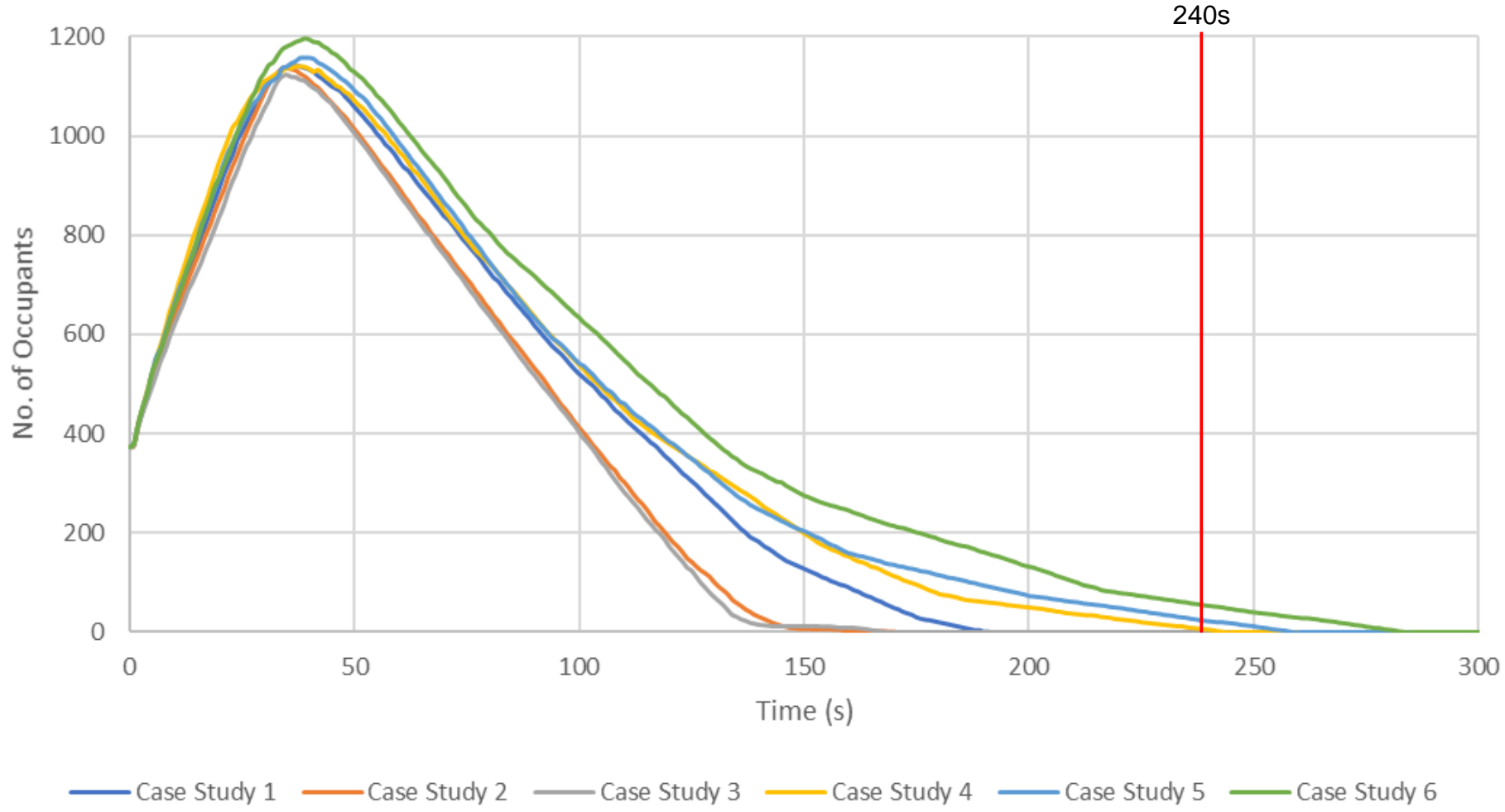


Case study	Cumulative Usage of Exits		Platform Clearance Time	
	Station Entrance	Escape Staircases	Lower	Upper
Case study 1	10.6%	89.4%	3min:12s	3min:23s
Case study 2	22.7%	77.3%	2min:51s	3min:27s
Case study 3	26%	74%	2min:49s	3min:35s
Case study 4	32.4%	67.6%	4min:4s	2min:52s
Case study 5	46.7%	53.3%	4min:19s	3min:27s
Case study 6	55.7%	44.3%	4min:44s	4min:4s

Cumulative Distribution of Exit Usage (Summary)



Lower Platform Clearance Time



Conclusion / Future Research

- Room queue time cost factor does effect on exit usage/platform evacuation time, to a certain extent
- Final exit location does impact on exit usage/platform evacuation time
- Varying locations of final exits as a possible option to “promote” occupants to use familiar routes for evacuation
- User judgement important as a sanity check of results (layout / familiarity of exit routes)
- Research for data on choice of familiar / unfamiliar exits by passengers in subway stations

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THANK YOU