



VERKÍS
CONSULTING ENGINEERS

Fire and crowd evacuation modeling in a low ceiling sport arena

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FEMTC conference, September 2014



Introduction

In October 2014, Iceland will host the European TeamGym championships in Reykjavik



- 4 days of competition
- 700 to 1.000 participants
- Up to 20 participating countries
- Seating capacity: 4.200 spectators

- Problem: There is no indoor stadium readily suitable for this event
- Solution: Use the Athletics & Exhibition Hall and install temporary seating stands



Completely different from original configuration



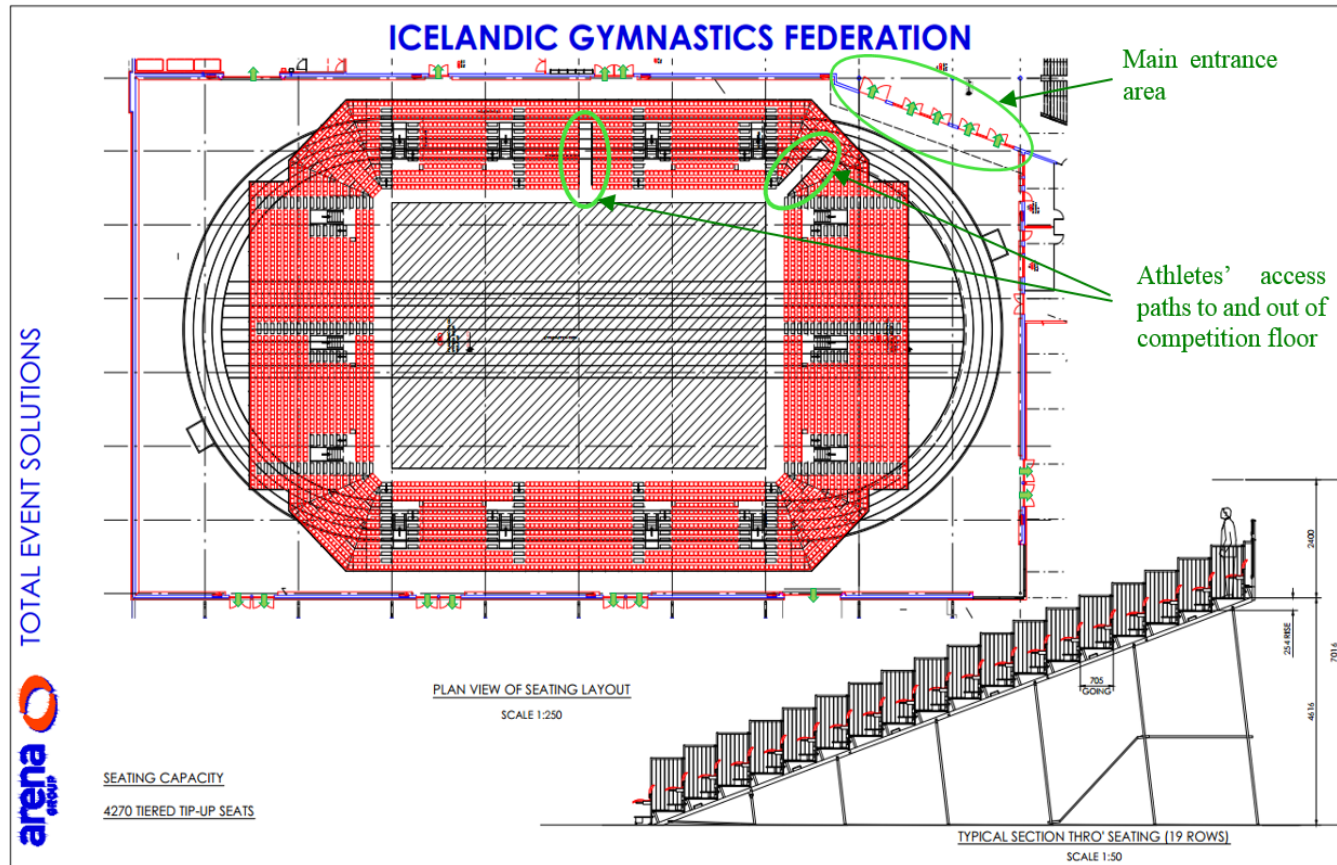
Need a new fire risk assessment

A landscape of colorful volcanic hills under a blue sky with a red text box. The hills are covered in patches of green, yellow, orange, and red, suggesting volcanic ash and mineral deposits. The foreground is a flat, grey, gravelly area. A red rounded rectangle is centered over the middle of the image, containing white text.

The fire safety problem

- 5000 m²
- Ceiling height between 8.35 and 11 m
- walls are made of concrete
- Roof made of steel supported by a metallic truss structure
- Smoke extraction: 7 mechanical vents placed on the roof.
- 18 different doors for evacuation





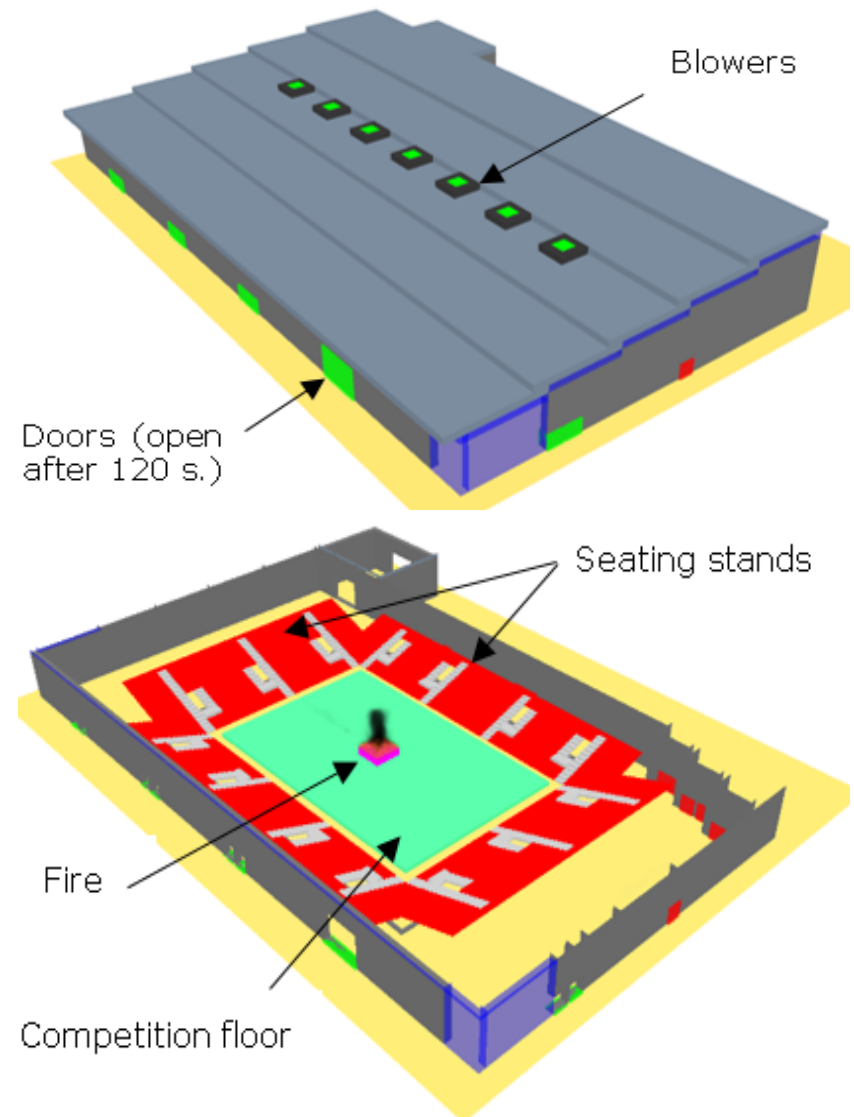
- Ok with British Standard for number of seats, rows, etc..
- Simple analytical NFPA model gives 4.2 minutes

- Low ceiling building
- Densely crowded and narrow paths
- **Panic!!**

A wide-angle landscape photograph showing a large body of water, likely a glacier lake, with several icebergs floating in it. The foreground is a dark, rocky volcanic shore. In the background, there are snow-capped mountains under a blue sky with scattered white clouds. A red rounded rectangle is overlaid on the center of the image, containing the text "Fire and smoke modelling" in white.

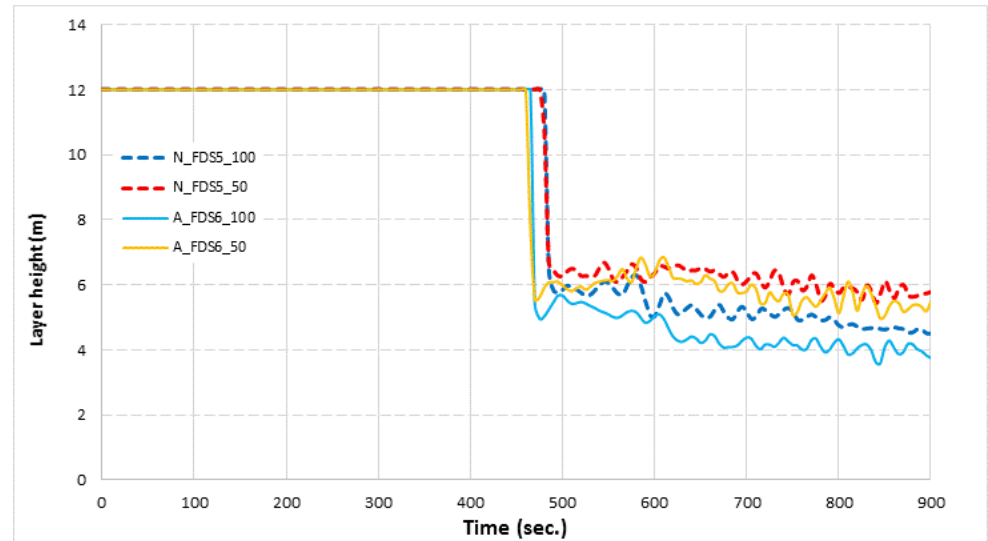
Fire and smoke modelling

- Domain: 100 x 75 x 15 m
- Doors open after 120 sec. Air intake: 28 m²
- 7 blowers (total: 50 m³/s. Start after 120 sec.
- Mesh resolution: 100, 50 and 25 cm (7.200.000 cells)
- Design fire: 10 MW medium
- Criteria: 10 m visibility at 2 m above floor
- Every scenarios simulated in normal and adverse conditions (blowers not functioning)

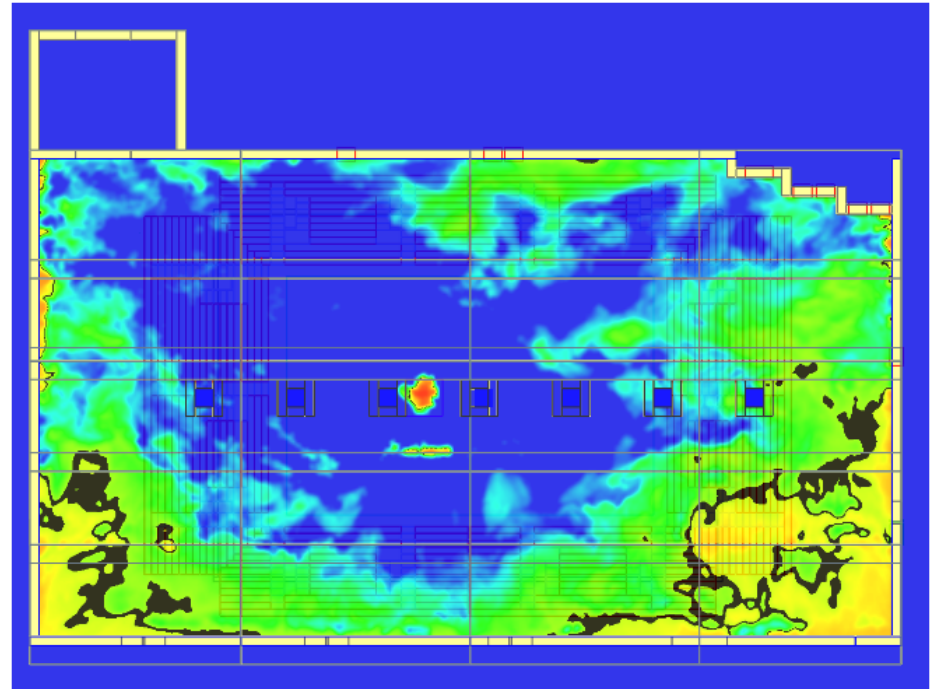
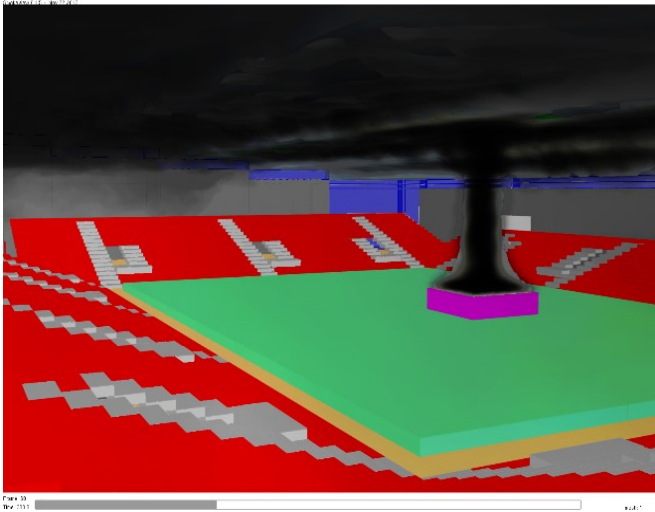


run	Layer height		t_{crit_st} (s)
	Format. time (s)	Height (m)*	
N_FDS5_100	480	5	690
N_FDS5_50	475	6.1	790
N_FDS6_100	465	4.2	630
N_FDS6_50	460	5.7	720

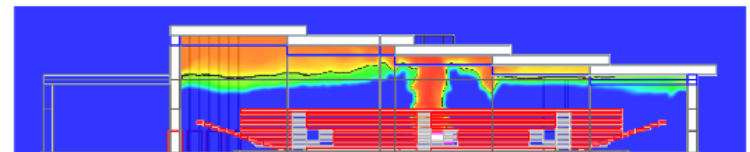
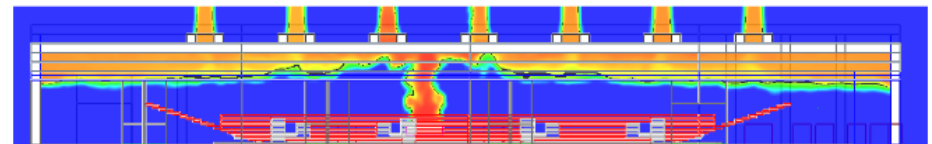
(*) Average value of the layer height between 600 and 900 sec.




- Mesh sensitivity
 - Layer height stabilizes between 1.1 and 1.5 m higher with a finer mesh (both with FDS 5 and FDS6)
- FDS5 vs FDS6
 - layer height stabilizes between 0.4 and 0.8 m lower with FDS6 than with FDS5
 - With FDS6, the layer height forms sooner, and the critical time is 60 seconds shorter. **Results are more conservative**
 - Higher CPU cost with FDS6 (it doubles!!)



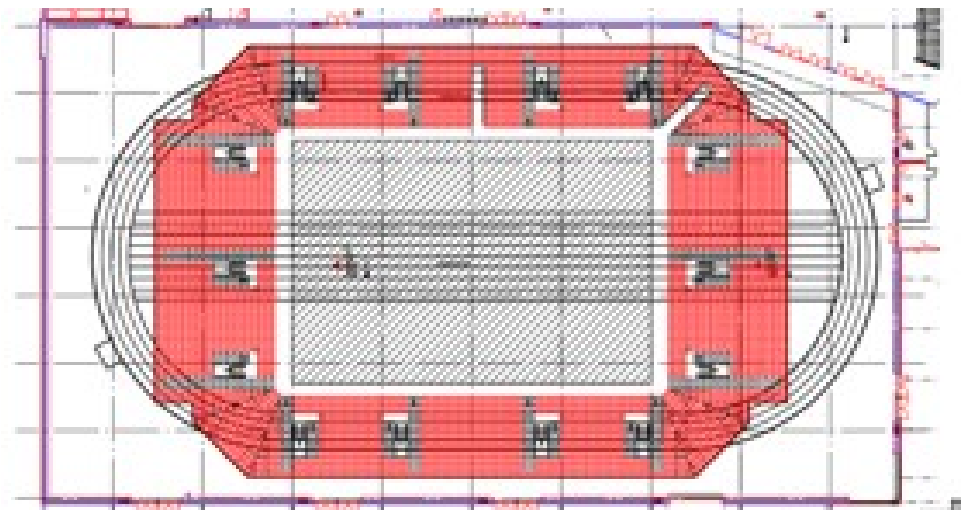
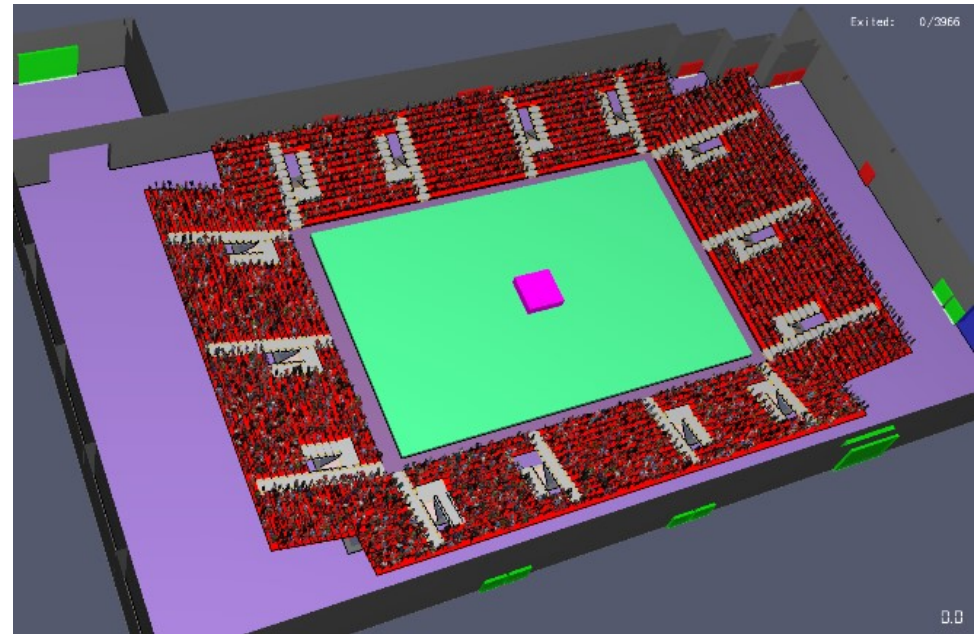
- t_{crit_st} [N_FDS6_25]: 670 seconds.
- t_{crit_st} [A_FDS6_25]: 520 seconds.

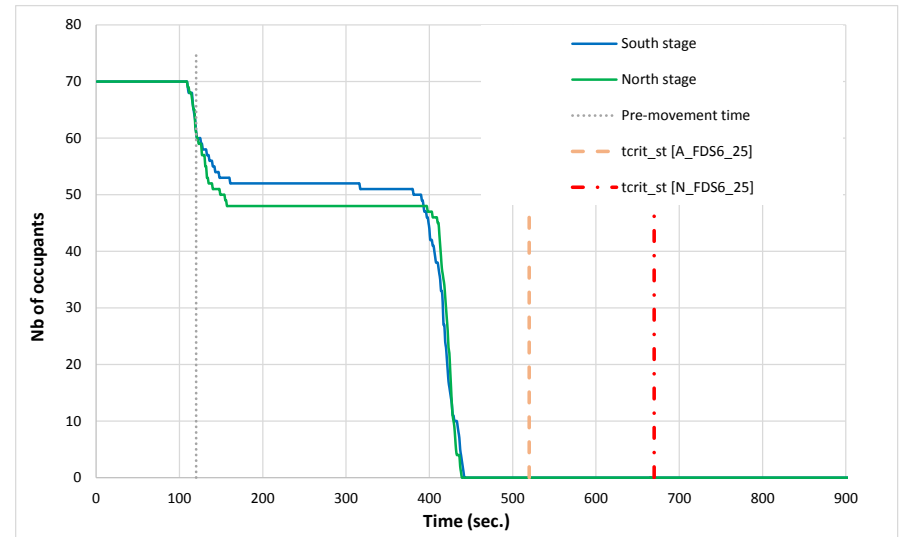
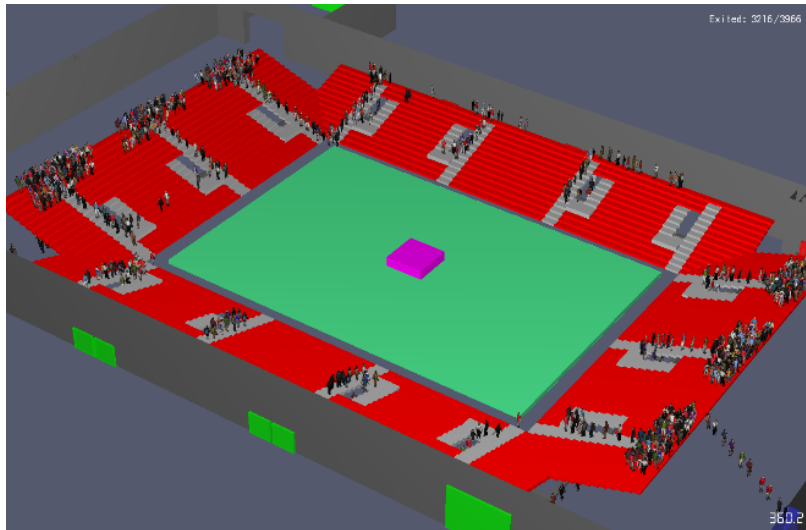
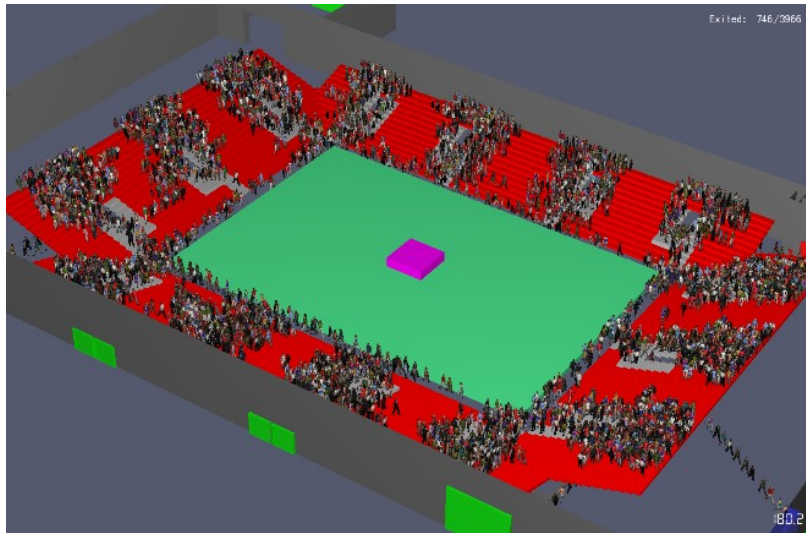


A scenic view of a river flowing through a rocky canyon. The river is in the foreground, surrounded by large, dark grey boulders. The canyon walls are composed of layered rock formations. The sky is blue with white clouds. A red rounded rectangle is overlaid on the center of the image, containing the text "Evacuation modelling".

Evacuation modelling

Stand	<u>Nb of rows</u>	<u>Height of row</u>	<u>Nb of occup</u>	<u>Nb of occup (highest row)</u>
South	18	4.5	1013	70
West	13	3.25	970	100
East	13	3.25	970	100
North	18	4.5	1013	70
Total			3966	

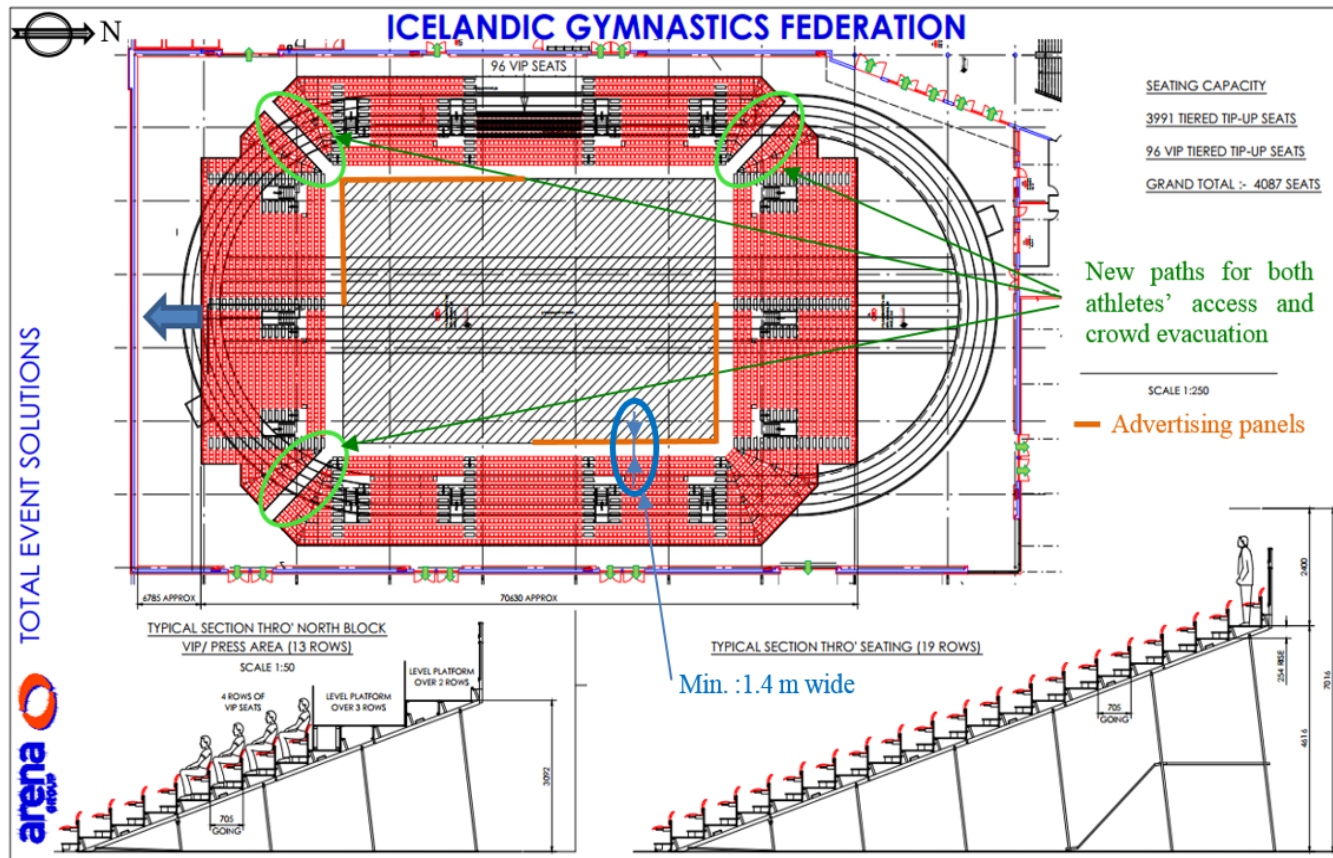




- Evacuation of the highest rows completed after 442 seconds
- Complete evacuation of the hall (stands + ground floor) achieved after 478 seconds



Stands layout is fine if all goes as intended



- New path from the competition floor to outside
- Ensure a 1.4 m with path between advertising panels and stands (creation of alternative routes)
- Move the stands and competition floor to the south

A landscape of colorful hills, likely the Rainbow Mountain in Peru, under a clear blue sky. The hills are covered in vibrant, multi-colored mineral deposits in shades of red, orange, yellow, green, and blue. A red rounded rectangle is overlaid on the center of the image, containing the word "Conclusion" in white text. The foreground is a flat, greyish gravelly plain. A white vertical bar is on the left side of the image.

Conclusion

Run	FDS	Pathfinder	Safety margin
	t_{crit}	t_{evac}	$(t_{crit} - t_{evac})$
N_FDS6_25	670	442	228
A_FDS6_25	520	442	78

- Even in adverse, there is still a sufficient margin for safe evacuation
- Alternative routes were created to account for difficulties (panic)
- Agreement was made to allow 4200 occupants in the hall
- Results were more conservative using FDS6, compared to FDS5

Thank you! Any questions?

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INTEGRITY



AMBITION



INITIATIVE