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Fire and crowd evacuation modeling in a low ceiling sport arena

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Introduction

The European Teamgym Championship

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

Laugardalshöll Sport Arena

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

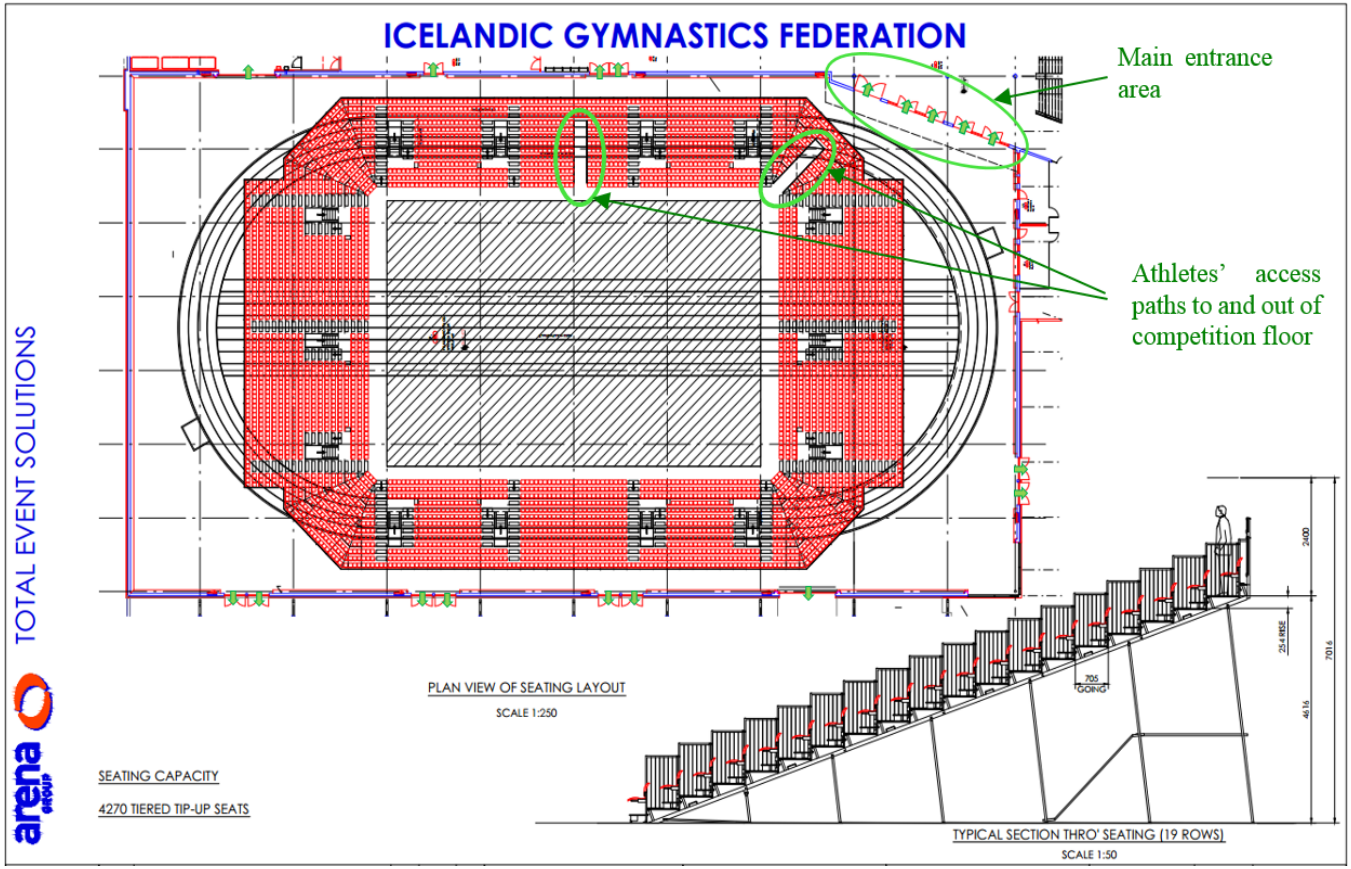
Completely different from original configuration → **Need a new fire risk assessment**


The fire safety problem

The Athletics & Exhibition Hall

- 5000 m^2
- 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

The building and stands layout



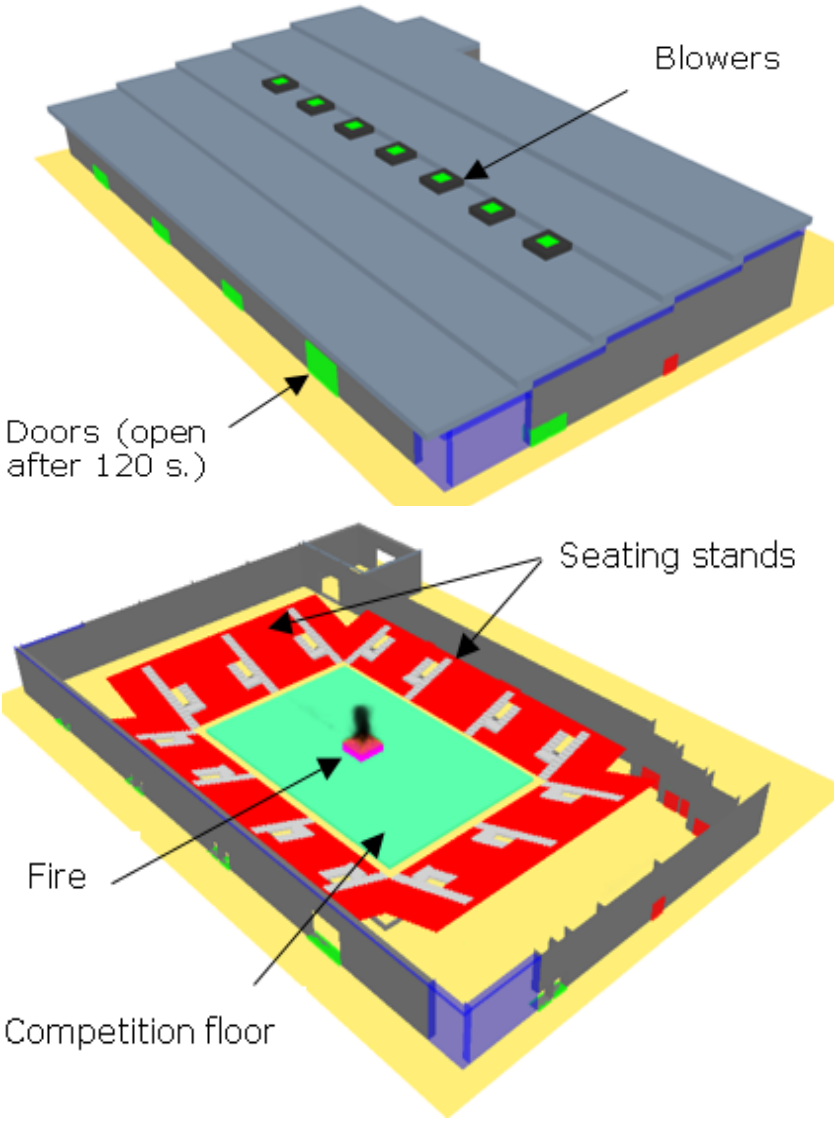
- Ok with British Standard for number of seats, rows, etc..
- Simple analytical NFPA model gives 4.2 minutes

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


Fire and smoke
modelling

The FDS model

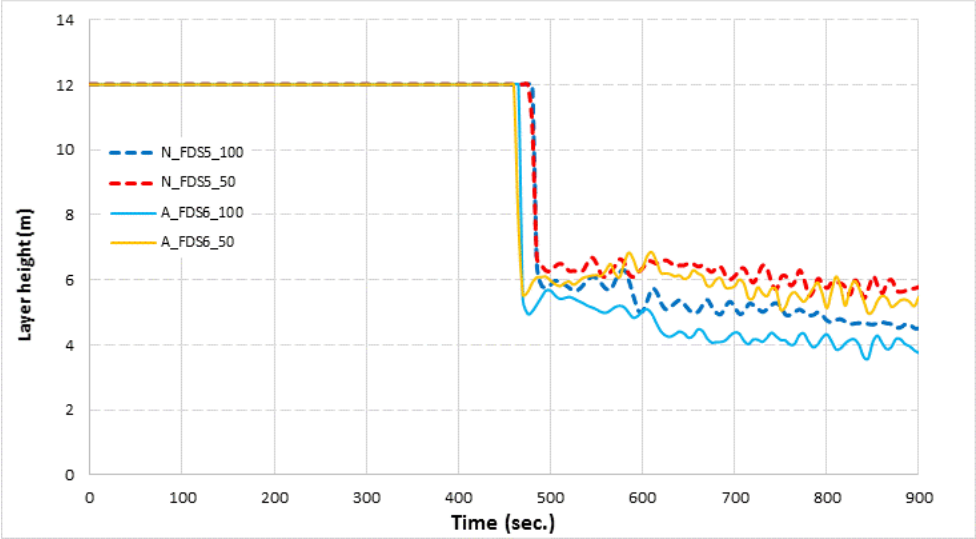
- Domain: 100 x 75 x 15 m
- Doors open after 120 sec. Air intake: 28 m^2
- 7 blowers (total: 50 m^3/s. Start after 120 sec.
- Mesh resolution: 100, 50 and 25 cm (7.200.000 cells)
- Design fire: 10 MW medium
- Criteria: 10 m visibility at 2 m above floor
- Every scenarios simulated in normal and adverse conditions (blowers not functioning)



Mesh sensitivity – FDS 5 vs FDS6

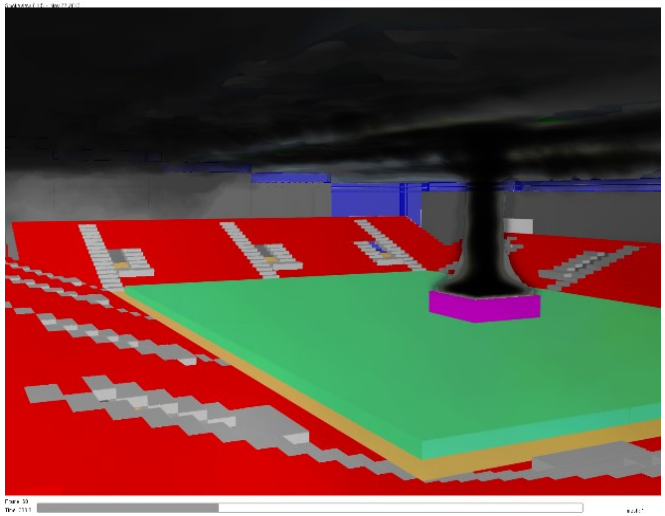
run	Layer height		t_{crit_st}
	Format. time (s)	Height (m)*	(s)
N_FDS5_100	480	5	690
N_FDS5_50	475	6.1	790
N_FDS6_100	465	4.2	630
N_FDS6_50	460	5.7	720

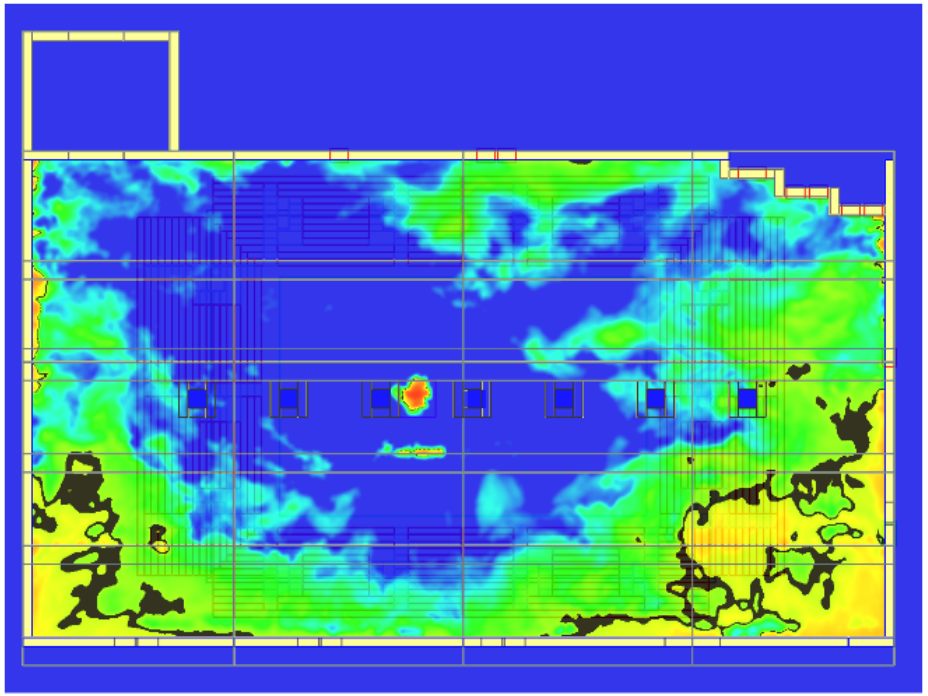
(*) Average value of the layer height between 600 and 900 sec.



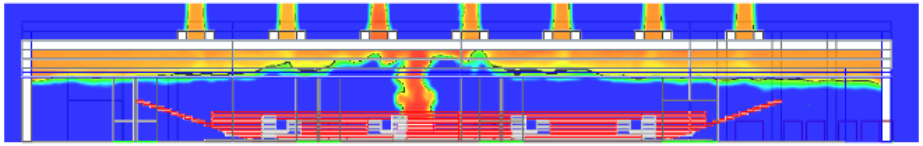
- Mesh sensitivity
  - Layer height stabilizes between 1.1 and 1.5 m higher with a finer mesh (both with FDS 5 and FDS6)
- FDS5 vs FDS6
  - layer height stabilizes between 0.4 and 0.8 m lower with FDS6 than with FDS5
  - With FDS6, the layer height forms sooner, and the critical time is 60 seconds shorter.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

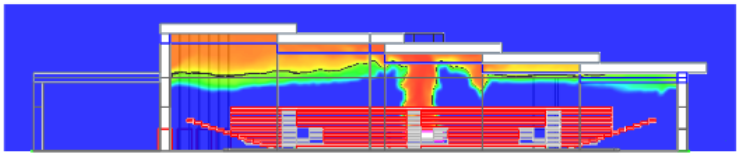
The FDS model





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

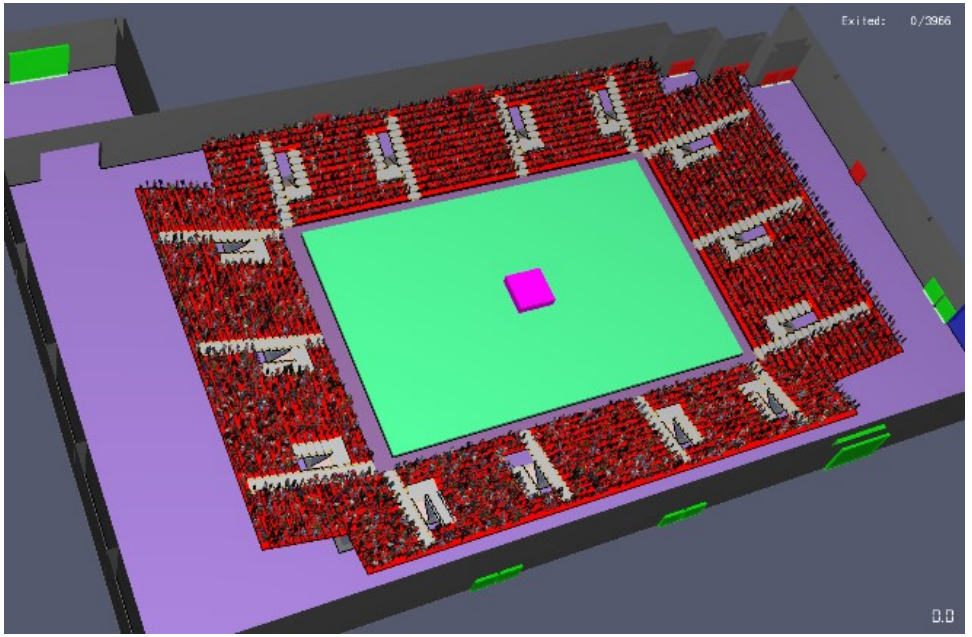


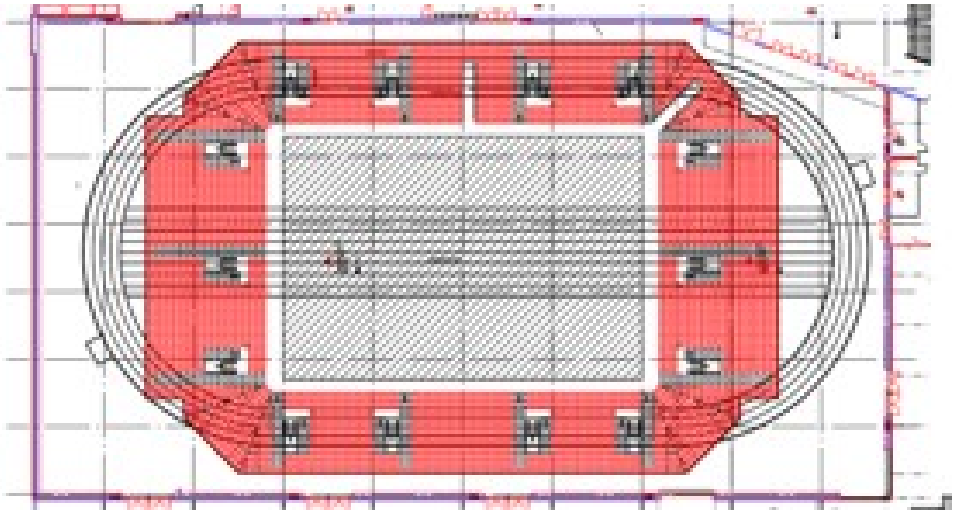



Evacuation
modelling

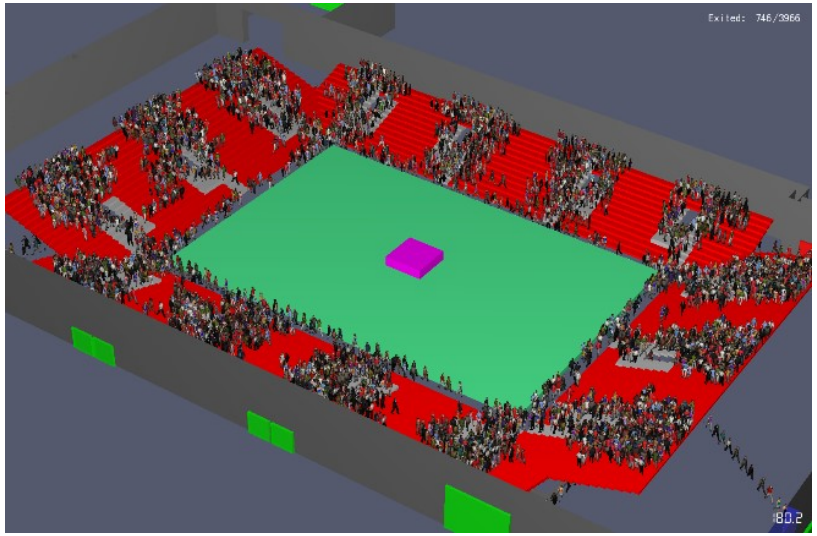
Pathfinder model

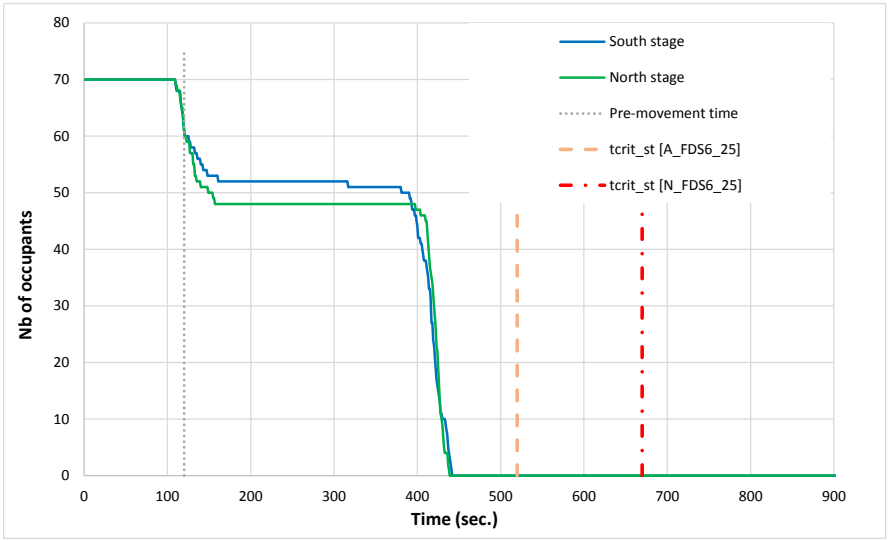
Stand	Nb of rows	Height of row	Nb of occup	Nb of occup (highest row)
South	18	4.5	1013	70
West	13	3.25	970	100
East	13	3.25	970	100
North	18	4.5	1013	70
Total			**3966**	

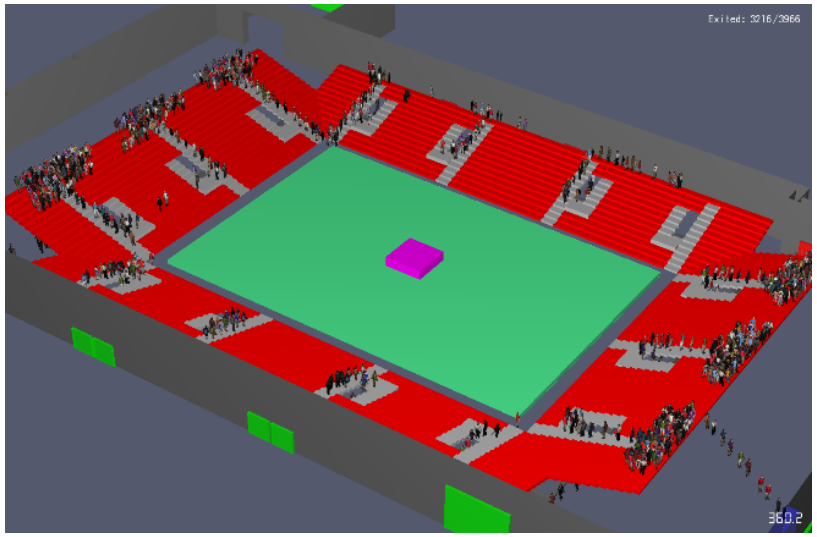




Pathfinder model



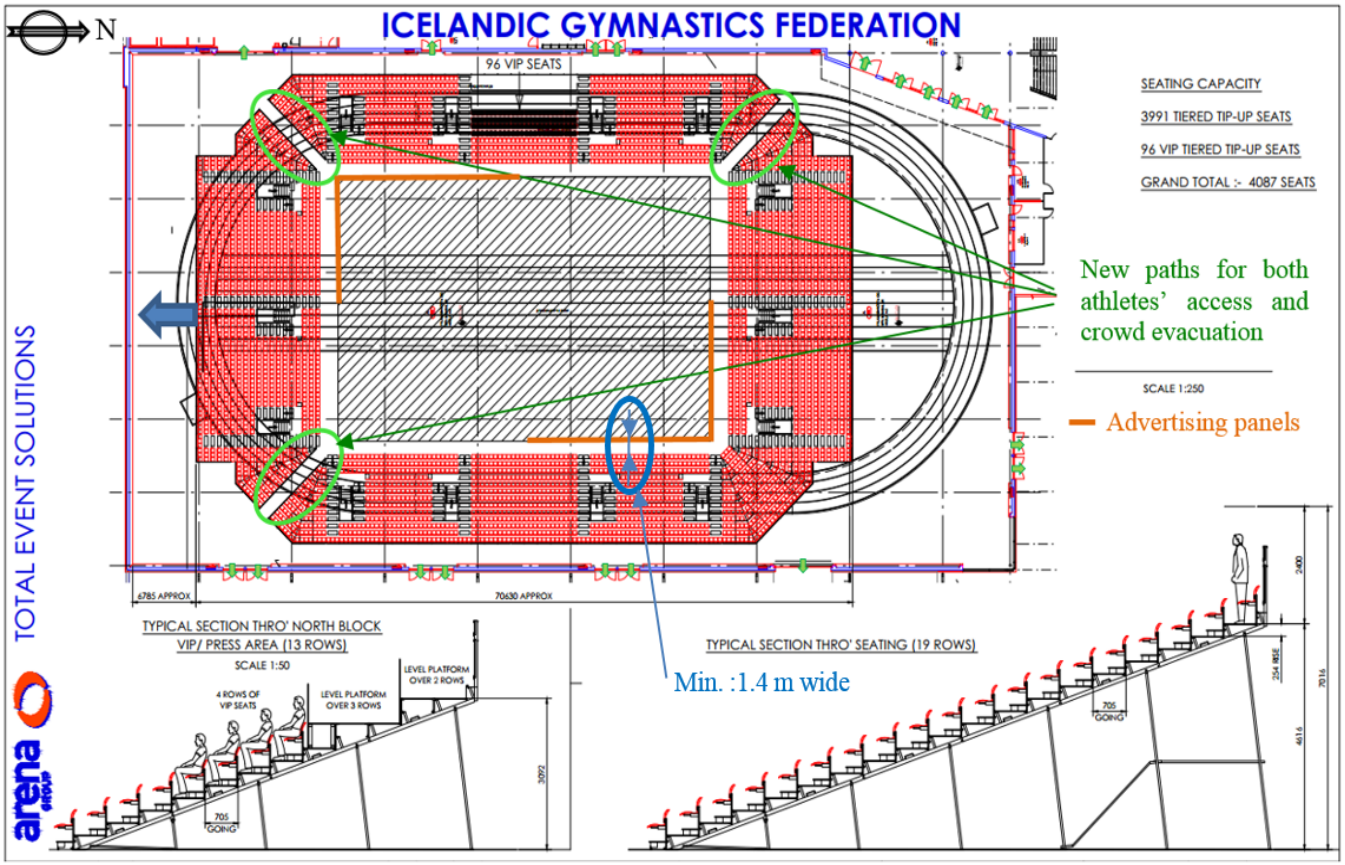




- Evacuation of the highest rows completed after 442 seconds
- Complete evacuation of the hall (stands + ground floor) achieved after 478 seconds

Stands layout is fine if all goes as intended

Modifications to the original layout



- 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


Conclusion

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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AMBITION

INITIATIVE