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STADIUM EGRESS AND BLEACHERS CONNECTION TO STAIRS AND EXIT PLATFORM

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ABSTRACT

Compared with other types of constructions (office building, train station, airports), stadiums are specific and very interesting cases.
Fast emptying of a stadium containing tens of thousands fans is not only something you should achieve in case of emergency but also a task that needs to be efficiently managed every time you have a match, a concert or political meeting. In this presentation we will see how bleachers connection to stairs and exit platforms can affect overall efficiency of egress process. FIFA authorities require full evacuation of bleachers in less than 8 minutes for any stadium of more than 20 000 seats. Large stairs and exit platform of course make evacuation faster and easier. But the larger the stairs and platforms are, the less room you have for seats and the less paying fans you'll be able to welcome.

This presentation is about bleachers geometry and its impact on egress efficiency but also on how we can simulate these very specific geometries in Pathfinder.
Can a pathfinder simulation have enough weight to make architects and real estate developers modify their design?

Based on the real case of Abidjan 30 000 fans football new stadium upgrade for the African football cup we compare two different options proposed by architect to connect bleachers to exit platform. A Pathfinder model of each option is shown and overall egress efficiencies of these two options will be compared.

STADIUMS

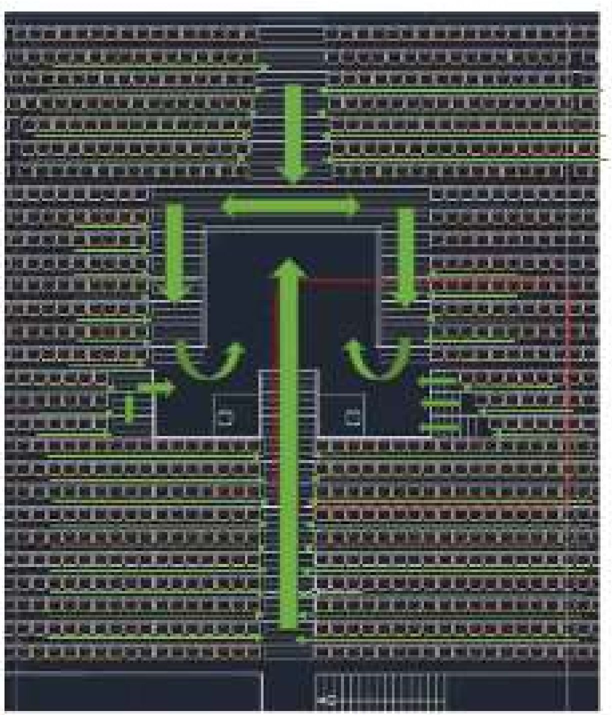
Competition for space:

Stadiums are places where a very high density of seated people can be seen. Circulation areas, stairs, exit holes in the structure are in direct competition for space with seats. Seats are of crucial economical importance as this is the number of seats that defines the capacity of a stadium and, therefore economic viability.

Figure 1: Part of Abidjan football stadium.

Abidjan stadium evacuation principle:

In most stadiums crowd exit platforms are called in French "Vomitoirs" (Vomitory) which gives an interesting idea of how people are supposed to exit the stadium (in bulk and fast…). Once up, people usually have to queue on a very narrow alley in front of seats to reach a stair that will lead to an exit platform and a vomitory. Then there is usually a short walk in a more or less open space under the bleachers.



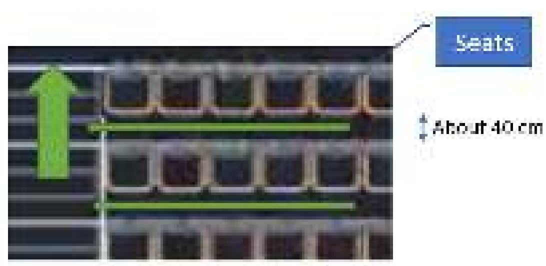


Figure 2: Evacuation principle

SPECIFIC CASE OF BLEACHERS

Bleachers are complex architectural objects. Detailed geometry of bleachers with seats and stairs are often too detailed and not adapted to pedestrian simulation software for the following reasons:

- Stairs have connections every other step with side alleys.
- Room in front of seats is very narrow. Most of time narrower than agent diameters.
- Stairs can be “pyramidal”.
- Surfaces are not perfectly horizontal, nor in the same plane. This is made on purpose to facilitate water flow in case of rain.
- Concrete surfaces have dilatation plastic joints that cause issues when directly importing Autocad or ifc files.

Copy/paste, translations & rotation with copy + copy from one model to another facilitate modeler work and we finally realized that building a library of typical bleachers prefilled with agents is an efficient way to have a better workflow during model building.

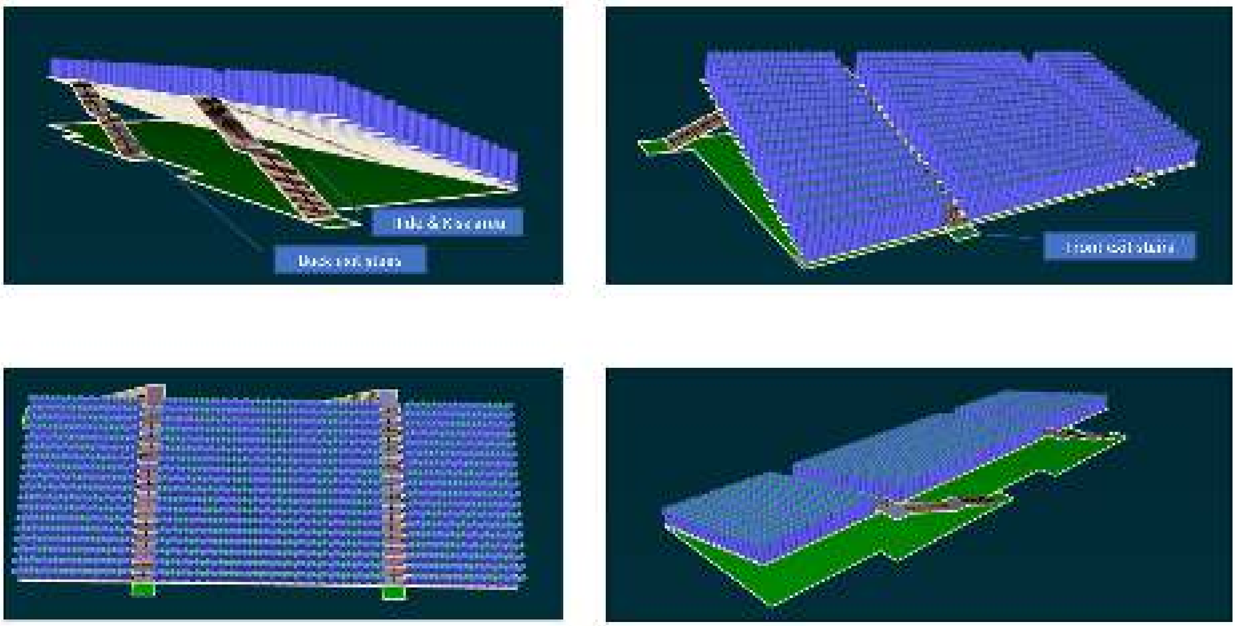


Figure 3: standard bleacher from premade object library.

CASE STUDY OF ABIDJAN FOOTBALL STADIUM

Overall simulation of stadium evacuation showed an evacuation of this 30 000 seats stadium in slightly less than 8 minutes.

One of the technical points to be decide for this stadium was about the geometry of exit platforms and its connection to bleachers. Two geometries were in competition:

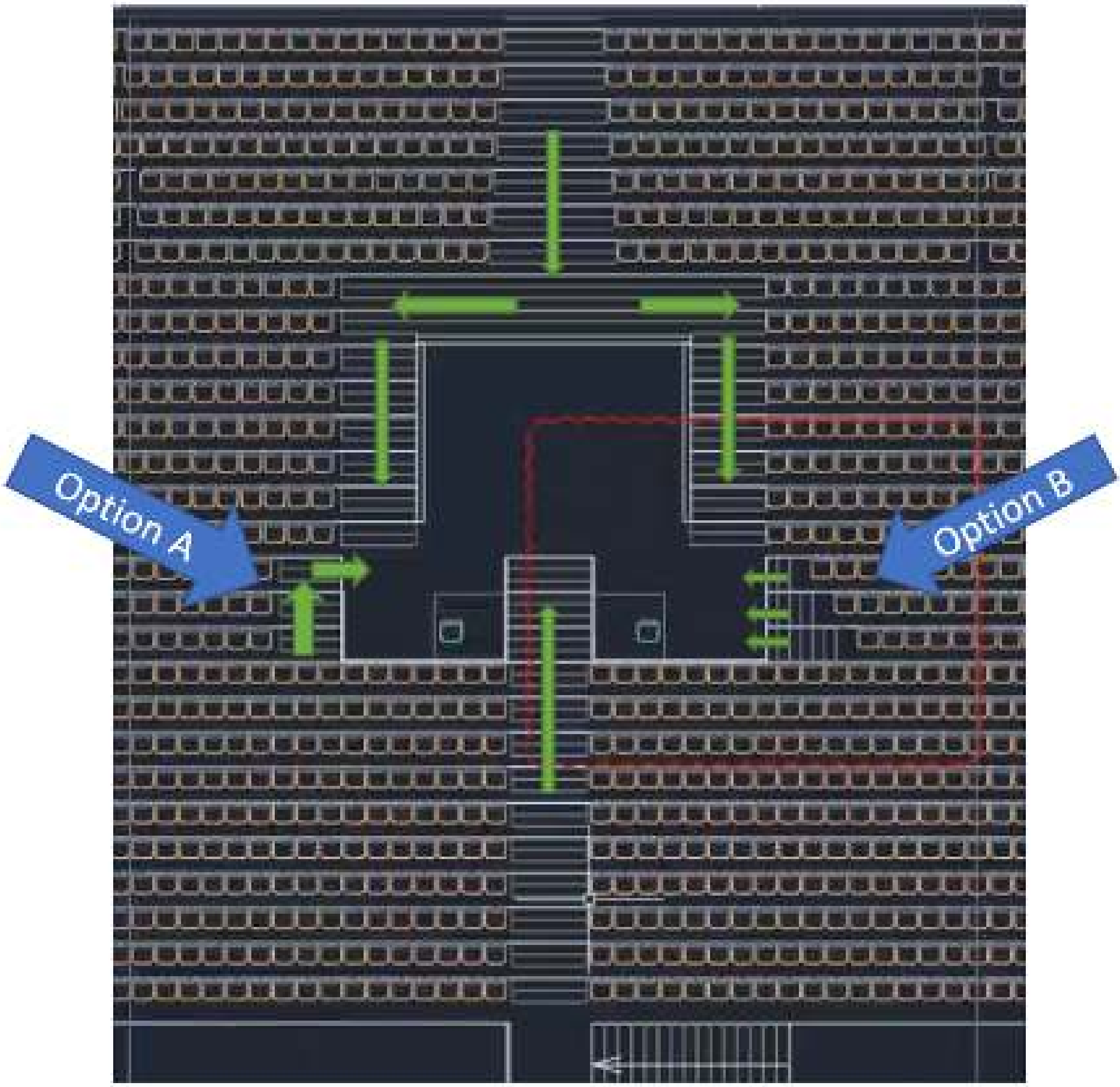


Figure 4: Illustration of two different ways to connect exit platform and side bleachers.

In the two geometries option A and option B are equivalent in terms of total number of seats. Surface devoted to stairs is identical in the two different options. It is also interesting to notice that the total number of seats concerned by these two options is quite limited compared with overall number of seats. In our Abidjan stadium case only about 5% of seats will be located in bleacher ranks that have to access exit platform by left and right sides.
Does this small amount of fans affect overall stadium emptying time if we choose option A or option B?

Pathfinder simulation :

A model of the two proposed options has been made using Pathfinder simulation software. To ease comparison and make sure only geometry impacts our analysis we decide to build the two bleachers side by side in Pathfinder using copy/past function to obtain option B modifying a copy of option A (including its occupants).

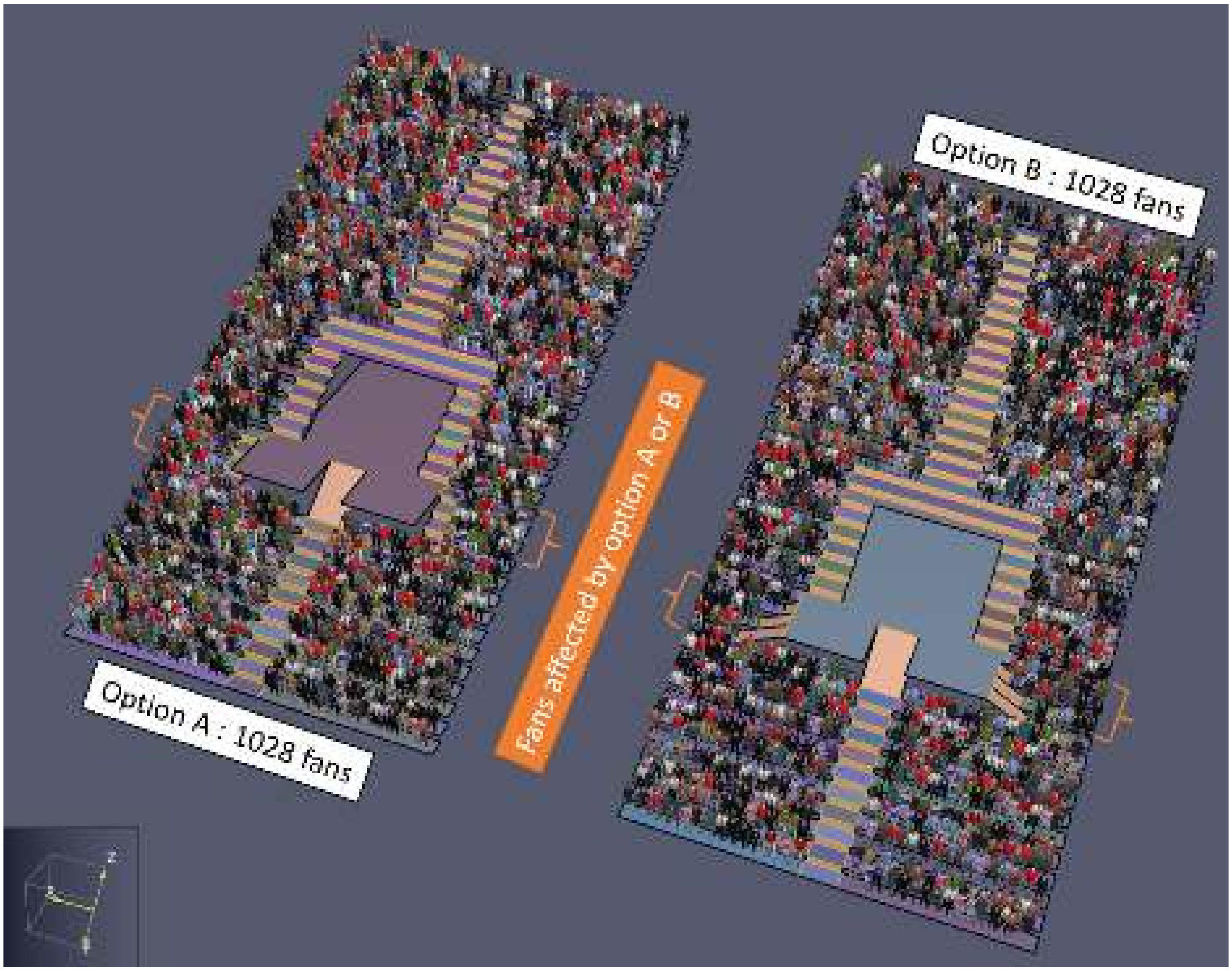


Figure 5: One model showing side by side both options.

SIMULATION & RESULTS

In our simulation, we can see that both bleachers' geometries result in a 5 minutes total evacuation time. Below screen captures show simulated situation for both options respectively 15, 30, 45 seconds, 3 minutes and 4 minutes after evacuation start.

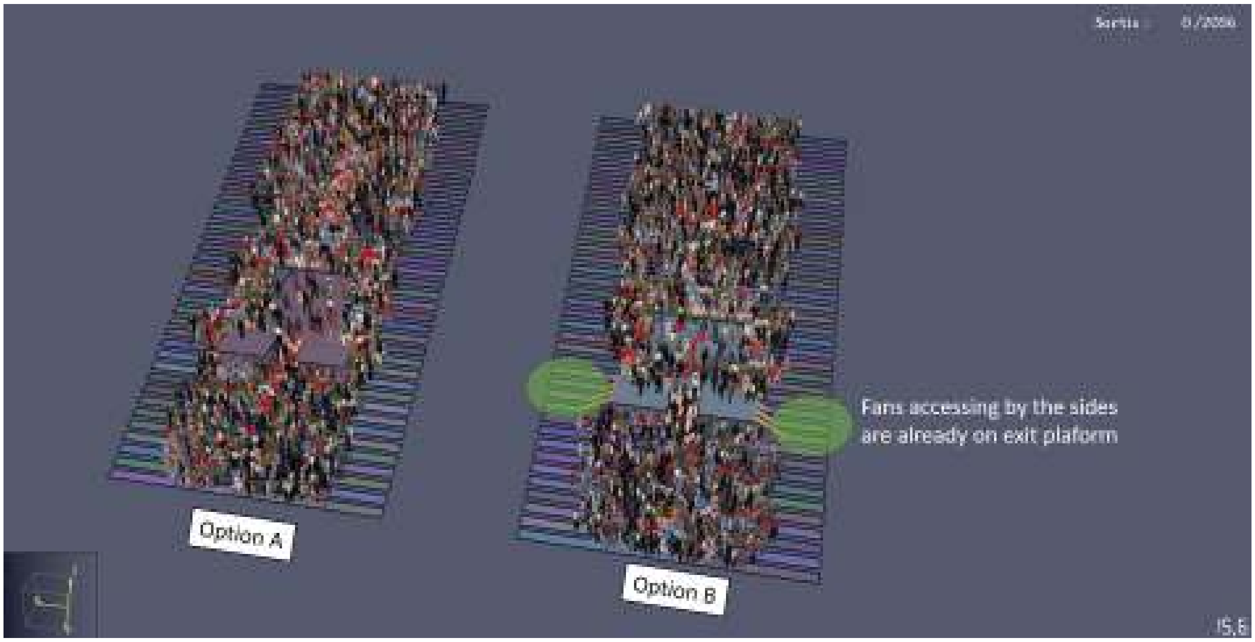


Figure 6: Situation after 15 seconds.

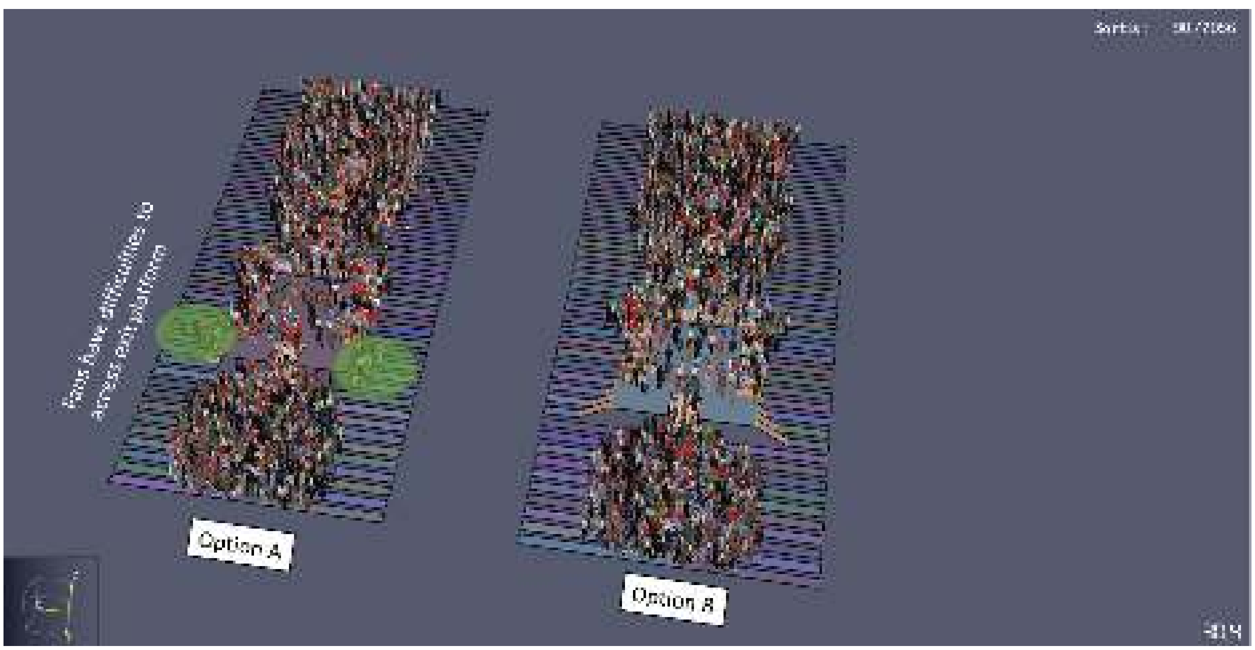


Figure 7: Situation after 30 seconds.

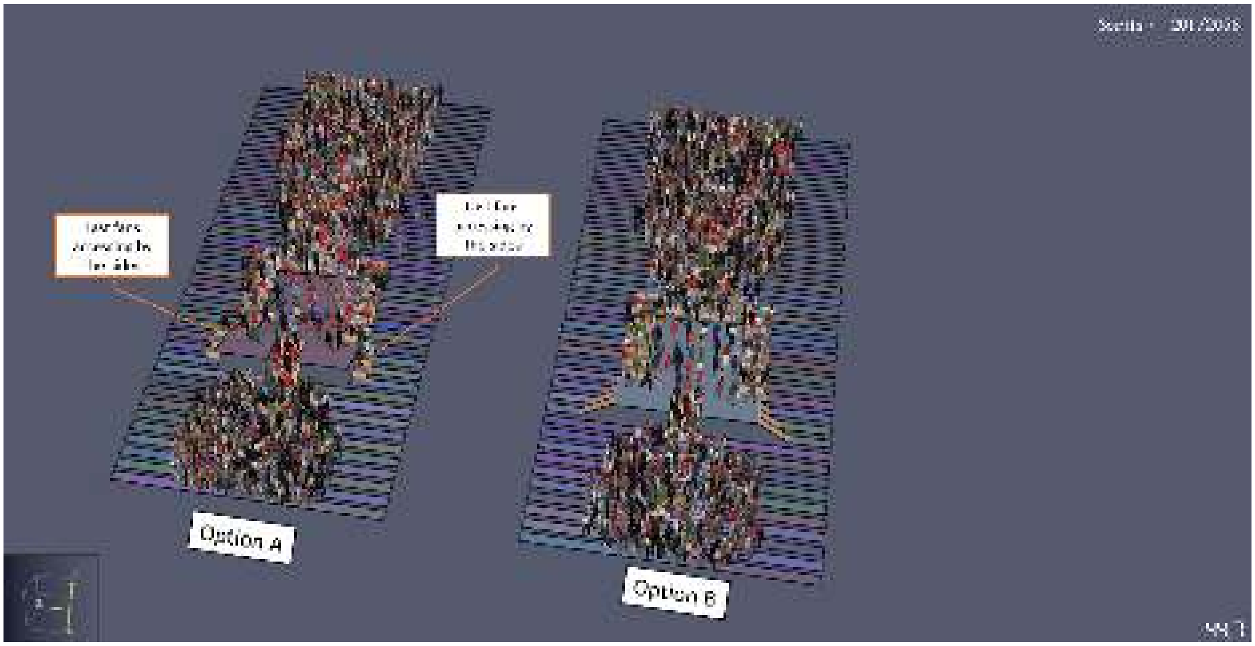


Figure 8: Situation after 45 seconds.

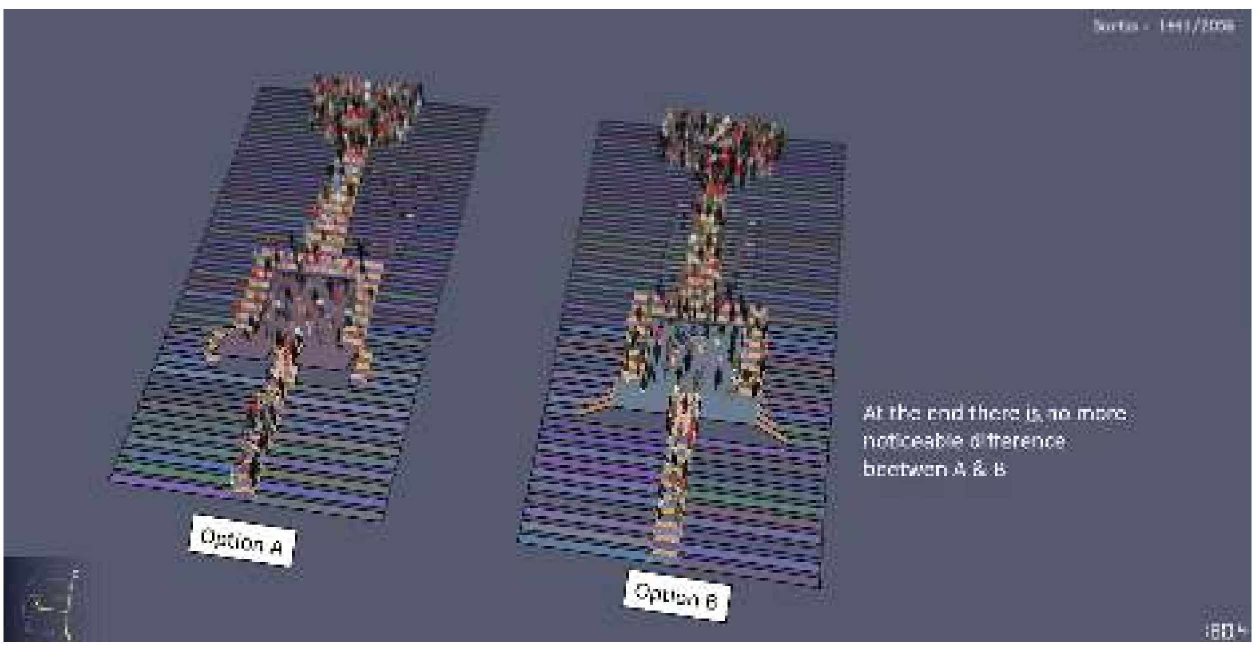


Figure 9: Situation after 3 minutes.

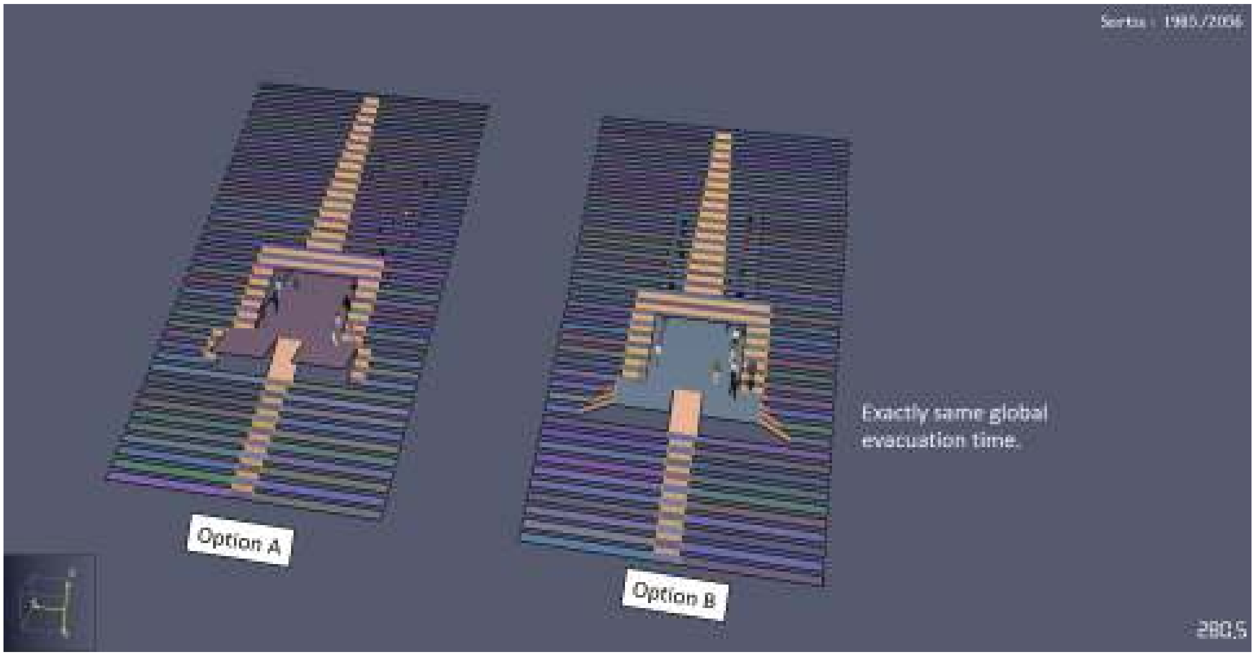


Figure 10: Situation after 4 minutes 40 seconds.

It is interesting to notice that none of the two options gives an advantage in terms of total evacuation time. But if we have a closer look at situation 15 seconds and 30 seconds after evacuation start, we can notice that for fans accessing the exit platform by the sides it does make a big difference. Option B is much more comfortable and allow faster exit. This is due to a better utilization of exit platform surface and less interactions with fans coming from upstairs.
This conclusion can lead us to another question: Why does this clear advantage of option B advantage does not have an impact on overall evacuation time?
If we take a look at exit rates for option A and option B over evacuation time, we get the curves in following figure.

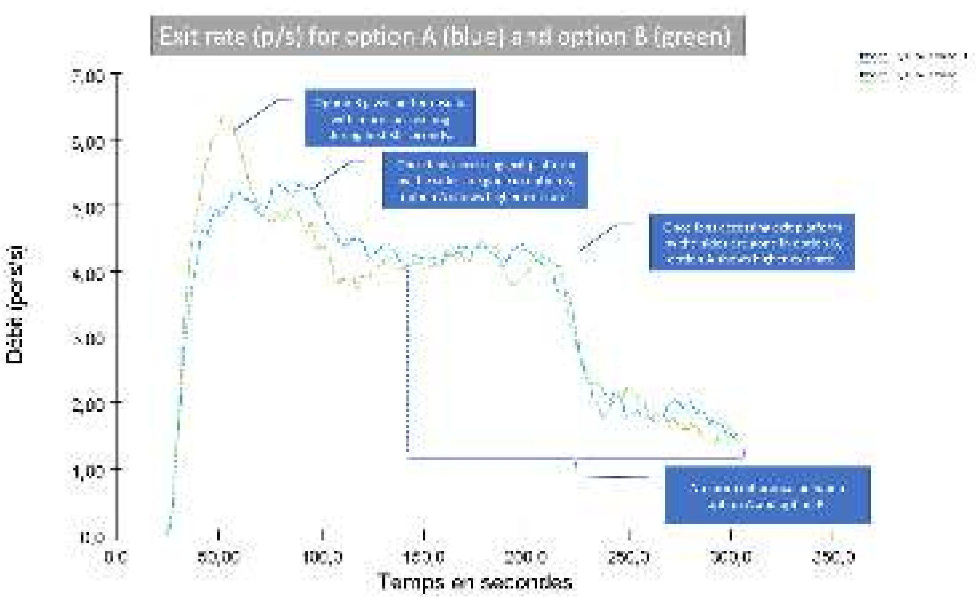


Figure 11: Exit rate over time in person per second

CONCLUSION

Using pedestrian simulation software can help architect taking decisions. Showing of on scale 3D animation with realistic pedestrians helps a lot to understand what could happen and take wiser decisions. In this specific case the "bad" case A would have been chosen if we had not do this simulation.

But a model remains a model. We all must remember that despite fancy and realistic animation a model is not reality. Don't be fooled by those little 3D animated guys walking or running in simulation models and always remember that behind the 3D animation agents are only cylinders. We have good reasons (and in situ observations and comparisons with models) to trust our models. Crowd movement and flow rates through doors are accurate and validated with reality tests (providing you do not stupidly change default agents' parameters). But we found that some geometries like bleachers are difficult to handle in simulation with non-flexible, non "seatable" cylinders. For us the question remains open on how to correctly model bleachers. Shall we stick on real geometry and reduce agents' diameters while they are in front of seats? Shall we simplify and remove seats? What about stairs in our bleacher's models? shall we have precise design of each step or shall we link levels with vertical ramps? All these questions would deserve tries, comparisons, in situ observations and debates. But we are consultants not researchers, time goes by and once one project is closed (and paid by customer) we jump to another different one and leave those questions for another time.