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Evacuation routes in a multi-story building

Using space syntax tools to improve users' safety

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ABSTRACT

Complex buildings can be defined by the amount and differences of the activities that will host. The case study, built in 1960 in Caracas, Venezuela, is a reinforced concrete structure of 8 floors and a single level of underground parking. It will be a future cultural hub that foresees to hold artistic groups and community services. The emergency evacuation system of the case study is outdated according to the 1978 and 1990 fire scaping norms of Venezuela, which states that for the characteristics of the building, it must have at least one pressurised staircase and elevator. The present research aims to serve as an approach of spatial configuration analysis of the existing building to shed some light on the decision making of future interventions concerning its escape routes and multiple vertical circulation options (several elevators and stairs without ventilation). A limited sample of the building is studied with spatial analysis methods such as justified graphs, axial maps, and Visual Graph Analysis (VGA) to provide data to improve the escaping routes of the building using spatial analysis tools, Agraph and DepthmapX, as opposed to the conventional evacuation modelling software.

For this study, comparisons were made with two different models, with links on stairs and elevators, for emergency events: with and without fire hazards. The analyses helped decide the escape routes and staircases that would most likely be used during an evacuation event and must carry on adjustments to comply with the current norm.

KEYWORDS

Multi-story building, evacuation route, stairs, elevators, vertical circulation

1 INTRODUCTION

More often than it should, design decisions of renovations are taken without proper methodological support; it is intended in the following document to settle the methodology to address the analysis of the spatial configuration of an existing building to shed some light on the decision making of future interventions based on the existing layout distribution and the vertical circulation options of the 'Casino' project. For that reason, a limited number of analyses are conducted to a sample of convex spaces with space syntax tools and software such as Agraph (version 3.0) and DepthmapX (version 0.80), to endorse with data and theory future design decisions.

This study aimed to research existing design issues of the study case to improve the safety of occupants during emergency evacuations. This study focuses on the passive evacuation routes of the building, namely staircases, elevators and nearby corridors, and this research aimed to use the capabilities of space syntax for that purpose.

When started this study, it was accepted that the safest route is the original core circulation, which staircase vertically covers across the eight floors of the system, and it is likely that the highest integration values of the system are grouped in and around this nucleus. The assumption is that floors with a high concentration of vertical passages, such as the existing ones on the fourth floor, are the spaces with the highest connectivity and integration and would be the most confusing place to leave the building during an emergency event.

In the chosen case study, with the need to comply with the pressurisation system protocols of the current fire escaping norms on its staircases and elevators, the main issue is to determine the best route from the existing alternatives and better manage the renovation resources. Hence, the purpose of using spatial analysis tools is to support with reliable spatial data the decision taking of which of the existing vertical circulation system and the spaces that lead to them should be prioritised for adjustments of pressurisation and signalled as an evacuation route. The final objective of further works is to compare the measures obtained from the analysis of the existing against the proposed layout and take design decisions to regulate the entries, movement patterns and segregation of the different groups of users of the circulation elements available, being those groups the resident managers and the visitors.

2 THEORETICAL FRAMEWORK

In Venezuela, fire scaping norms state that existing buildings with more than four levels built before 1974 must have at least one pressurised staircase when there are no stairs with natural ventilation (COVENIN, 1978). Some years later, this norm was complemented with the following: '(…) every building equal or greater than 25 meters height, shall have at least one lift with preferential call (...)' (COVENIN, 1990), an electrical system that allows firefighters the use of determined elevators while the electrical system of other elevators is not operating. Moreover, the same document states that: '(...) the lift shaft with preferential call shall be pressurised in accordance with the provisions of COVENIN norm 1018' (COVENIN, 1990).

Even though there are several evacuation modelling software available for planning and modelling evacuation routes within buildings, considering factors related to human behaviour and movement (Kuligowski et al., 2010) for determining evacuation routes of buildings; it was found that the model with the most similar characteristics to a simulation made with space syntax methods was the flow-movement modelling. In this method of evacuation planning and modelling, the assessment of the safest evacuation routes is used a factor 'travel cost', which is measured by the time and distance someone would take from any room of a building to a safe exit. This cost value would be given to any node and travel line of the different rooms and corridors (Şahin et al., 2019), and it is accepted from the different simulation modelling methods, that the points of congestion throughout the building would happen in the nodes and line segments of the path that people need to take to reach the outside. Currently is not possible to add cost values to the different elements of the space syntax models, namely the nodes, links, and segment lines; however, it is possible to get from the software predictive information related to user's choice and shortest routes with space syntax metrics that could serve for the same purpose. The election of space syntax methods for making the analyses is based in the fact that with these tools, it is possible to make an abstraction of the building without losing its structure of navigation (Behbahani et al., 2014). Moreover, these techniques have been demonstrated to be the ones that will provide reliable predictions of the movement of occupants, similar to the one provided by evacuation simulators.

Furthermore, since elevators are an important element of multi-story buildings and it has been demonstrated that when frequent maintenance is done, there is high reliability of emergency lifts (Turhanlar et al., 2013) for evacuating individuals with mobility impairments, these are also considered vertical transitional spaces. It is important to remark that the only scenario where elevators cannot be used as an emergency evacuation route is during a fire emergency (Kinateder et al., 2014), unless as states the Venezuelan norms, it is used by firefighters only.

2.1 Settings and Activities

The case study is a reinforced concrete structure of eight floors and a single level of underground parking built in 1960, on a lot of 951 m^2, located in the Candelaria parish in Caracas, Venezuela. The building worked as a casino from 1991 until it was closed in 2010 due to non-compliance with the gambling laws of 2007. Before working as a casino, the function of the building was of public offices; this use switch brought its first renovation, with the addition of different systems of vertical circulation, modifications made to serve to its new purpose of gambling space.

Nowadays, the building is undergoing its second renovation. The renovation aims to requalify the structure and serve as a cultural centre in downtown Caracas. The activities currently working on these floors: are a music and audio-visual studio, a serigraphic workshop, a coworking office, a skating ramp, and a welding and wood workshop. Furthermore, the layout renovation of the former casino is planned to split and merge some existing spaces to adapt it into its new uses. Currently, the building counts, in a scattered way with: three service lifts connecting from the basement to the fourth floor, which in its old times of casino was the service floor, two passengers elevators, the main staircase that goes from the basement to the terrace, a spiral stair and a hall staircase connecting from the ground floor to the fourth floor, and two independent stairs connection only two levels, one of them from the fourth to the fifth floor, and another from the fifth floor to the sixth floor, where are located the engine rooms of two of the service lifts. None of the staircases is pressurised for eventual fire events. There is a vehicular ramp from the basement to the street level on the east side of the lot.

3 DATASET AND METHODS

To gather information for further comparison, some criteria are defined in advance. The first step is to define the space syntax technique and the tool to process it to use according to the scope of the research. Next, it is necessary to identify the range of spaces to analyse, delimit and simplify convex spaces, make clusters if required according to the connection between floors.

The analysis includes transitions between floors through the stairs and a combination of stairs and elevators, having as a premise that in the scenario of emergencies that are not related to fire, it is possible to use lifts as part of the evacuation routes thus, each analysis was made using two models considering both scenarios; the scenario using stairs only is called 'Model 1' and the scenario using both stairs and lifts is called 'Model 2'.

Since this paper aims to analyse and assess the measures of stairs and elevators and convex spaces nearby stairs, stairs landings and elevators; each staircase and elevator shaft was defined as a convex space per floor, understanding that each the boundaries from one convex space are not related to build elements, instead of the visual and movement limitations (Hillier, 2007). The individualisation of stairs and elevators per floor allows identifying the movement and interaction that users may have with each segment of the staircase or elevator, both in local and global measures.

To guarantee that connection between the floors throughout the analysis, three different kinds of space syntax experiments are conducted for each model with the techniques of justified graphs, axial maps, and visual graphic analysis (VGA); from which it is possible to get topological based measures of a complex vertical system.

The tools for conducting the analyses are DepthmapX which is used to define the global and local measures of axial maps and VGA, and Agraph, a graph calculation software, in this study is used for defining the depth and segregation of the spaces from a determined point root in the floor plan.

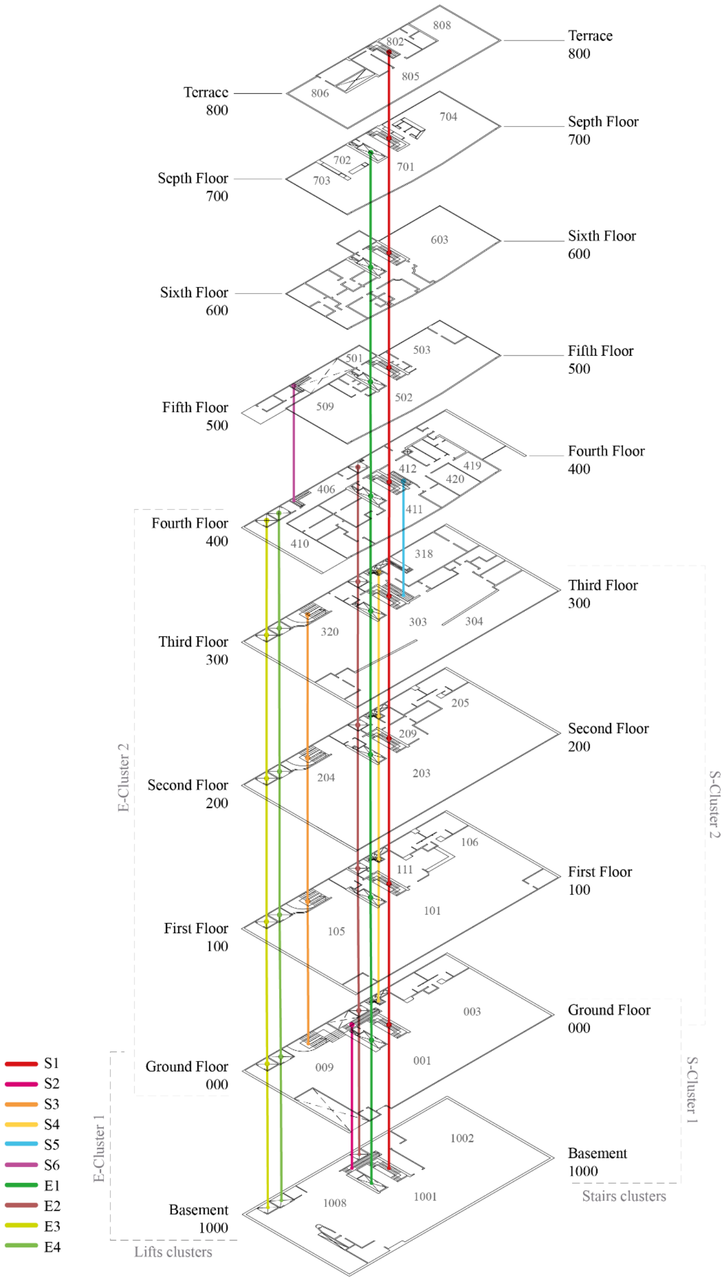

Figure 1: Vertical transition spaces and main convex spaces of each floor

Given that the different vertical circulation nucleus elements, such as landings, staircases, and elevators, might be mentioned through the analysis and discussion, it was also necessary to identify them properly. As shown in Figure 1, there are 6 staircases and 4 elevators shafts, identified with the letter 'S' as prefix and a number as the suffix for stairs, the letter 'E' as prefix and a number as the suffix for elevators. Figure 1 shows a diagram with the ID of each element for a clearer understanding of the navigation complexity of the circulation.

Moreover, for analysis purposes, the building was subdivided into 2 clusters, understanding in the study that clusters are floors grouped according to two or more stairs or elevators that commonly join them until reaching the ground floor. Hence, the first cluster for both scenarios connect from the basement to the ground floor. The second cluster encompasses the storeys from the ground floor to the third floor on model 1 and from the ground floor to the fourth floor on Model 2.

In the building exists detached stairs that are not part of clusters and do not lead to the ground floor, such as S5, which links the third floor and the fourth floor, and S6, which links the fourth floor to an isolated maintenance space on the fifth floor. In the case of E1 and S1 from the third and fourth floor onwards is not counted as a cluster since this would be the only egress exit for both scenarios.

3.1 Justified graphs

The first analysis was the comparison of justified graphs to understand the system in terms of integrity and depth in relation to a root node. This logical model is the one that has more similarities of abstraction with the flow-based model of evacuation simulation of nodes and line segments linking each node.

The justified graph comprises the whole system with its root in the entry, an outdoor space, on the ground floor level (see Figure 2). To simplify the diagram of justified graphs were joined different convex spaces which configurational structure repeats through the different levels. The main junction into a single node was the convex space of S1, its landing and E1. The same criteria were applied to E3 and S4 and their landings.

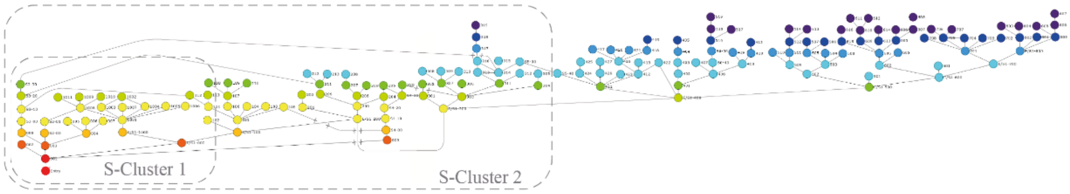

Figure 2: Justified graph of the system of model 1, arranged by total depth

The vehicular ramp in the basement is not defined as an exit since it is not expected to be used as an egress door in case of an emergency. Given that there is an aggregation of several spaces from the fourth floor and above, and there is only one stair as the scaping route, these values are not considered for this analysis and its conclusions.

3.2 Axial Maps Analysis

Experiments of axial maps were conducted with the same two models of connection between the vertical transitional spaces of the building using DepthmapX software. Similar to the experiments conducted by Brösamle et al. (2007), the link between floors was made by connecting axial lines representing each stair and elevator, then, with the use of the 'link' tool of DepthmapX was connected each axial line of stair or elevator of every floor, whether it was model 1 or 2, with its corresponding axial line on the upper or lower floors. The difference regards the experiments conducted by Brösamle et al. (2007), is that it was no used intermediary axial lines or widgets to make the link between stairs and elevators for the analysis. The representation of the connections that can be seen in Figure 3 and Figure 4 use a set of the fewest axial lines, and the connections of stairs are made directly to the axial line representing them into the axial map. The clusters defined previously are still used in the axial map analyses for making comparisons.

3.3 Visual Graphic Analysis

VGA analyses of all the floors were linked through the stairs in Model 1 (see Figure 5) and stairs and elevators in Model 2 (see Figure 6). Both VGA scenarios were ran using a grid spaced of 0,30 m (Parvin et al., 2008). To ensure the optimisation of analysis of the links, 3 cells of the convex space of the transition, whether stair or elevator, were selected to link to three cells of the upper or lower floor in the same space, resulting in a total of 6 cells linked per transition.
The measures compared are integration and global measures of visibility relationships though empirical overlay and observation of the changes between VGA and axial maps. Due to computation constraints, it was not possible to carry out local measure analyses.

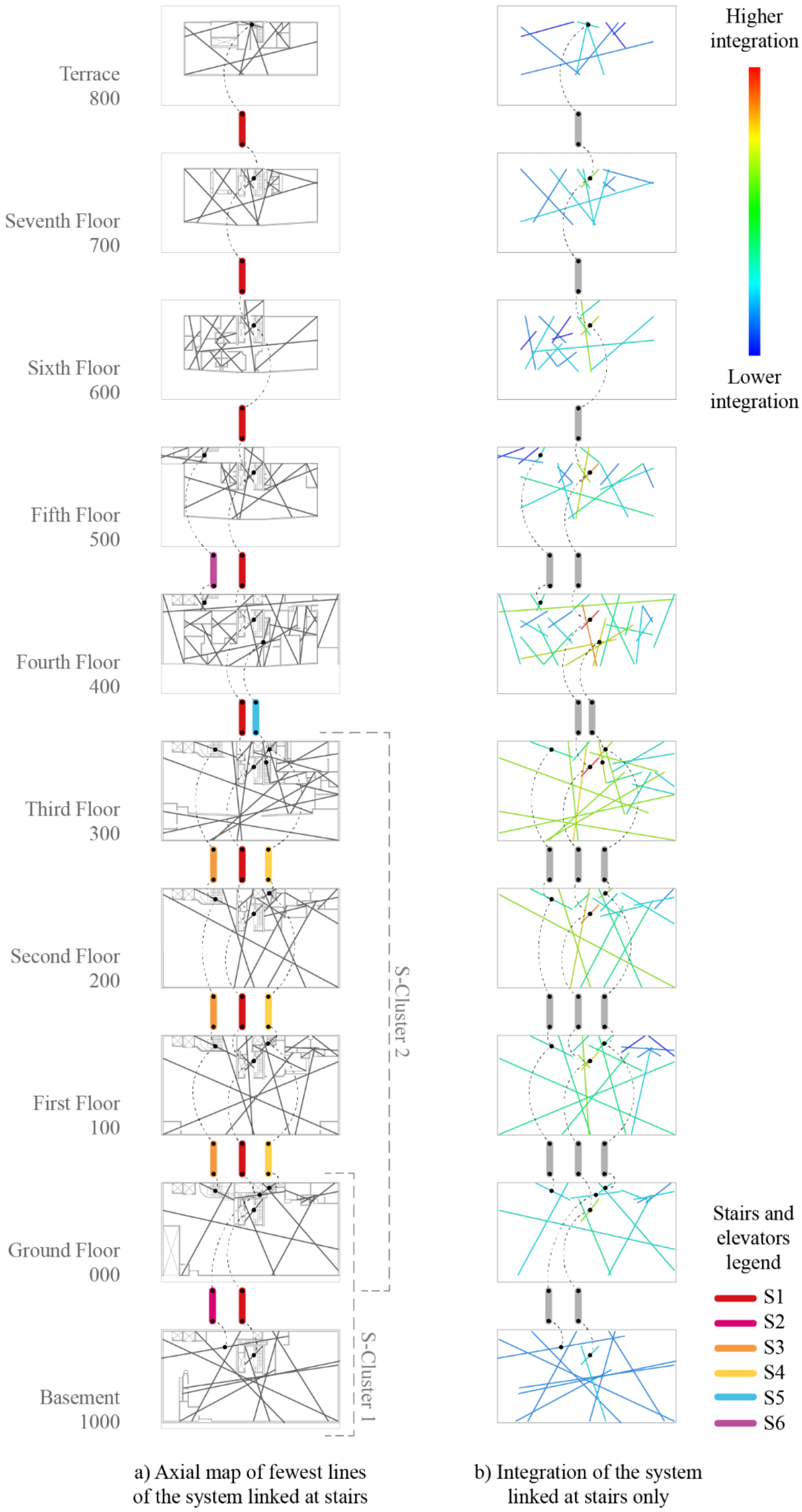

Figure 3: Axial map of model 1

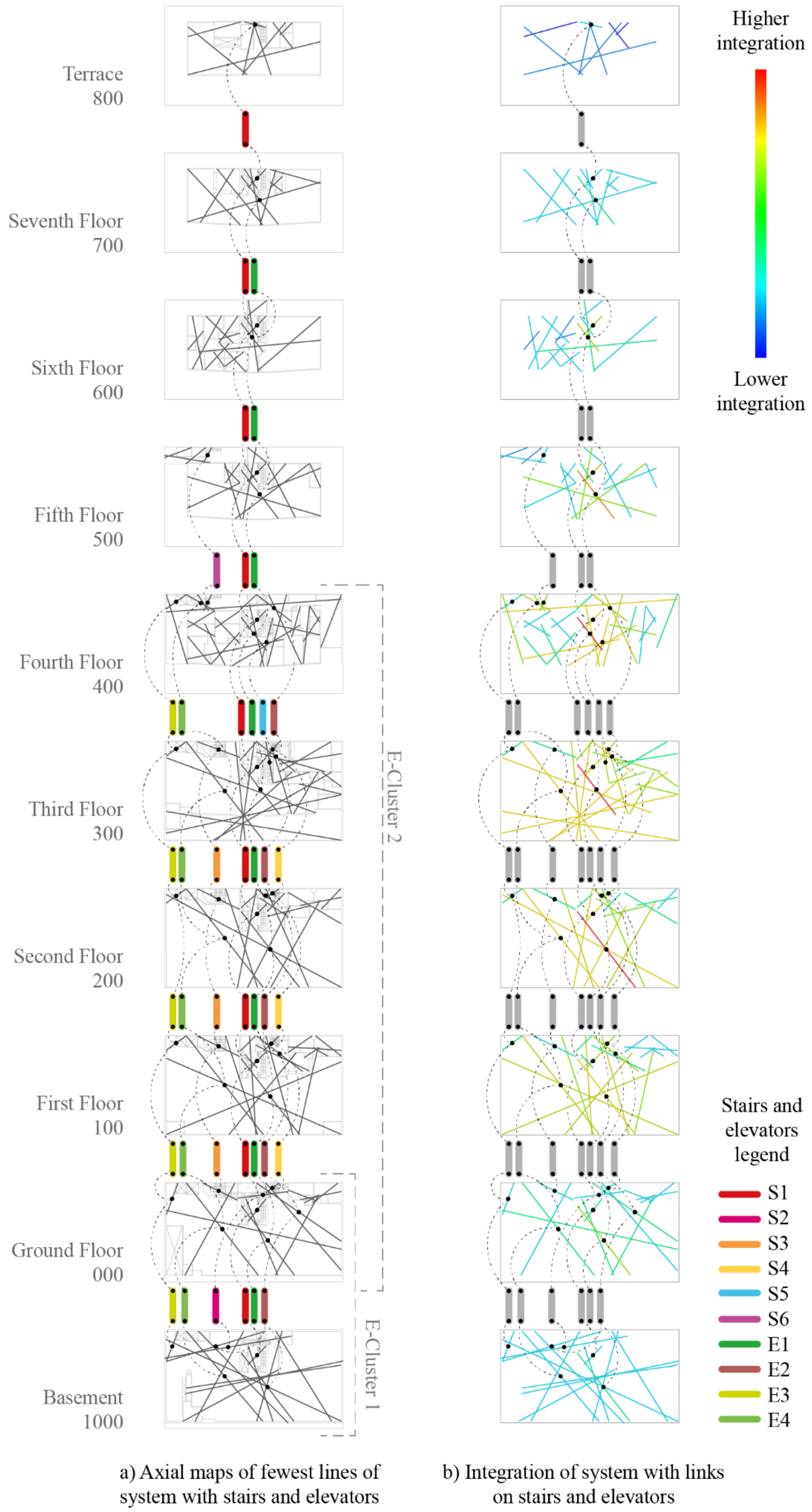

Figure 4: Axial map of model 2

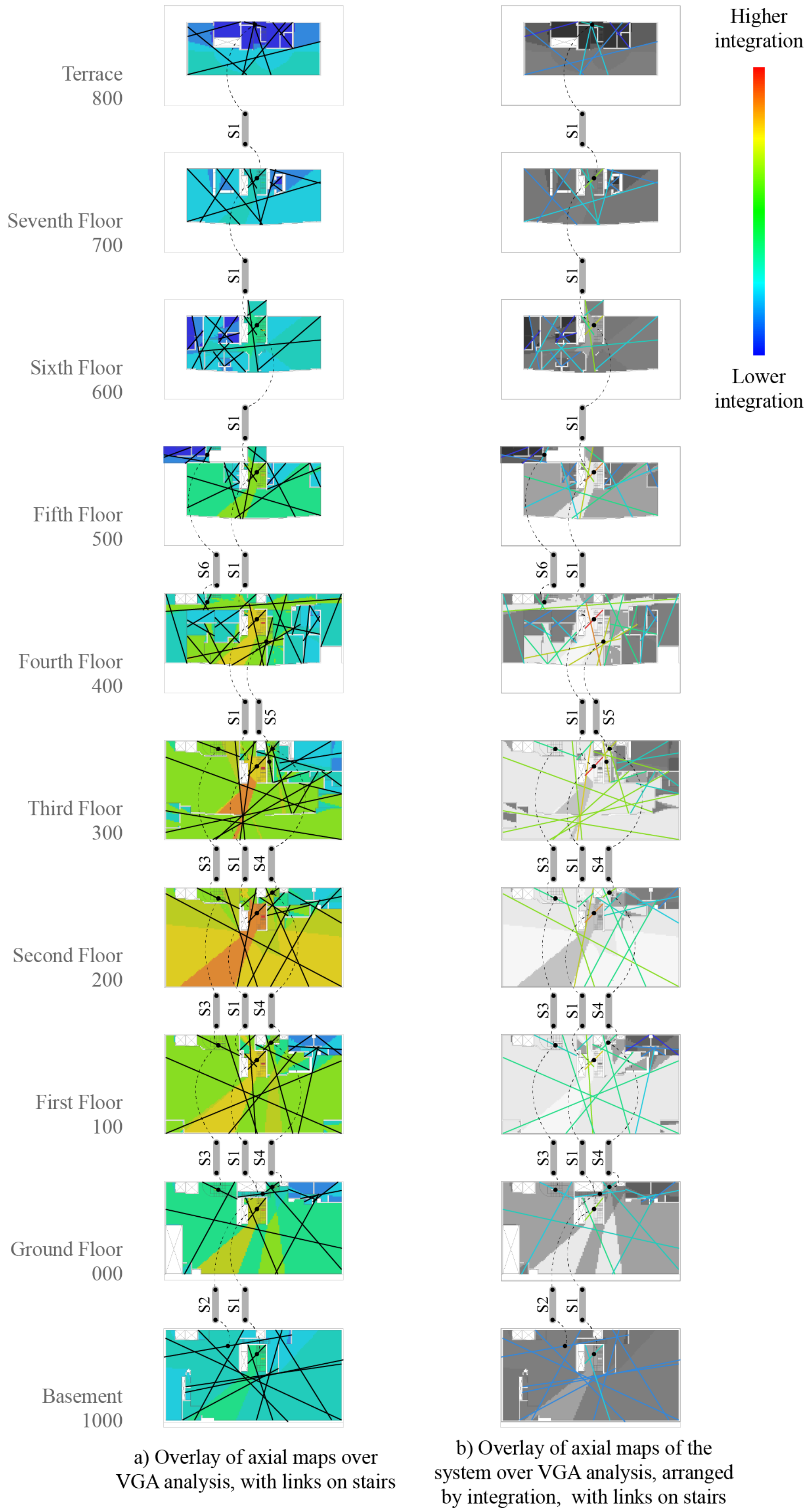

Figure 5: VGA Analysis with an overlay of axial lines, model 1

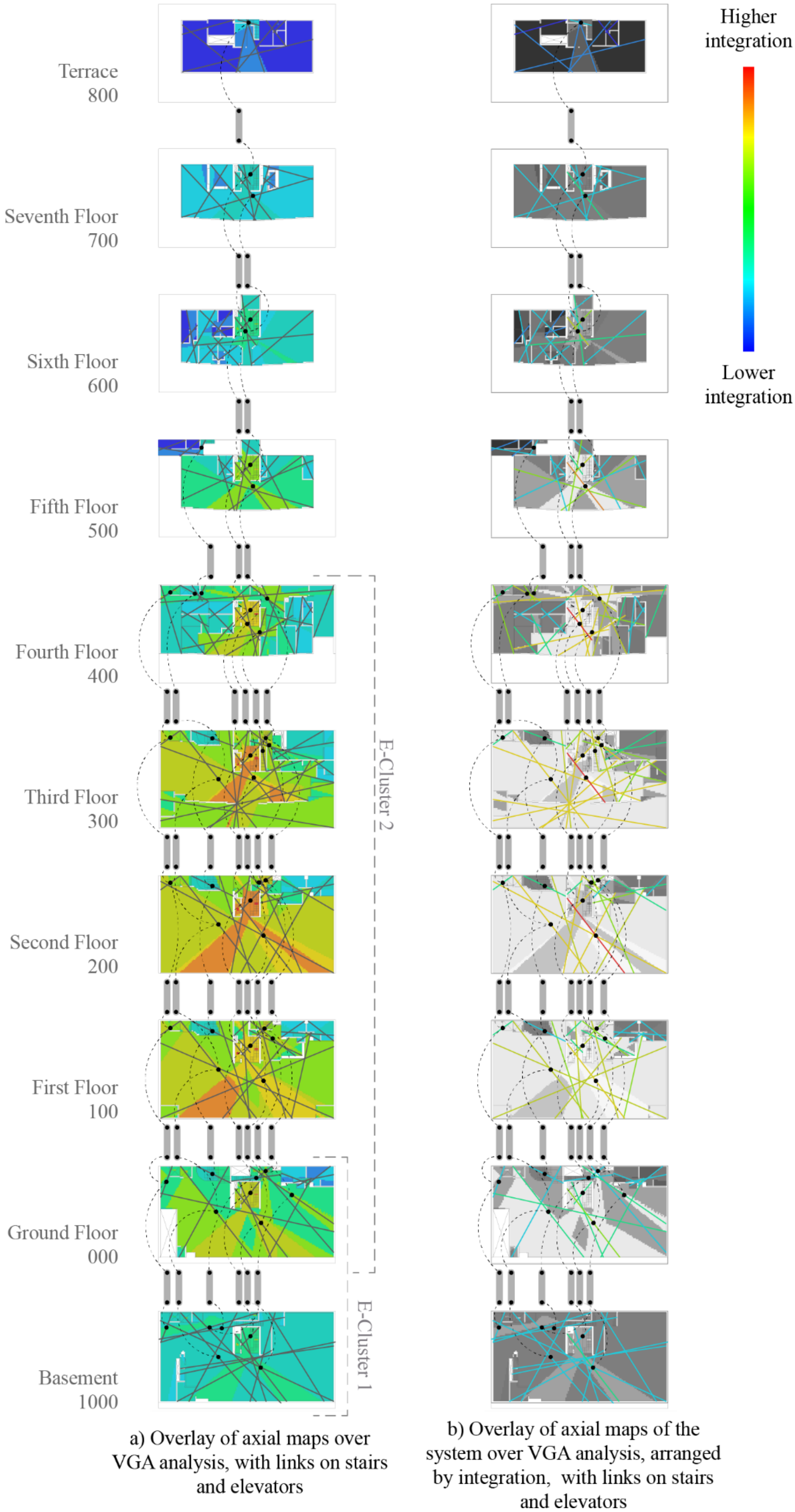

Figure 6: VGA Analysis with an overlay of axial lines, model 2

4 RESULTS

Generally, the vertical transitional space chosen as the main escape route should have the highest integration and shallower depth, ensuring accessibility during evacuations (Nilufar & Choiti, 2019). On the metrics of justified graphs of Table 1 are highlighted the most and less likely used stairs.

Table 1: Justified Graph metrics of vertical connections of Model 1

Level	S1		S2		S3		S4		S5		S6	
	TDn	i	TDn	i	TDn	i	TDn	i	TDn	i	TDn	i
Fifth Floor	857	19,81									1378	11,29
Fourth Floor	790	21,94							1135	14,13	1221	12,98
Third Floor	796	21,73			1219	13,00	1043	15,61	1035	15,75		
Second Floor	847	20,11			1264	12,47	1109	14,52				
First Floor	928	17,97			1345	11,61	1190	13,37				
Ground Floor	1041	15,65	1424	10,88	1458	10,59	1303	12,04				
Basement	1182	13,47	1565	9,78								

Of cluster 1, from the two existing stairs connecting the storeys, the most likely stair to be chosen as egress is S1 because it is the shallower and most integrated stair with the shortest route from the spaces of the basement that goes to the target level, the ground floor, where is located the egress door.

As shown in Figure 2, between the basement and the second floor, the depth of the spaces is even, but from the third floor onwards, spaces start to gradually segregate as the building grows in height, which reveals that on these first levels exists an intricate circulation system and that from the third level upwards, the options of vertical circulation are reduced.

Similar results were obtained from the analysis of Model 2, and represented in Table 2, which reveals that the safest and most intuitive route for the public is the set of S1 and E1, being the most likely and suitable egress exit to the ground floor.

Table 2: Justified Graph metrics of vertical connections of Model 2

Level	S1/E1		S2		S3		S4		E2		E3		E4	
	TDn	i	TDn	i	TDn	i	TDn	i	TDn	i	TDn	i	TDn	i
Fourth Floor	887	23,65							1108	18,00	1285	15,11	1285	15,11
Third Floor	878	23,96			1267	15,36	1093	18,30	1094	18,27	1144	17,32	1144	17,32
Second Floor	920	22,59			1314	14,72	1126	17,65	1119	17,79	1156	17,11	1156	17,11
First Floor	1002	20,33			1380	13,91	1223	16,01	1213	16,16	1245	15,68	1245	15,68
Ground Floor	1120	17,77	1497	12,67	1498	12,66	1343	14,35	1334	14,46	1364	14,10	1364	14,10
Basement	1263	15,41	1617	11,61					1411	13,56	1511	12,53	1511	12,53

The second safest route is the set of E2 and S4, and the less safe route is also for the public, is the set of E3, E4 and S3. Compared with justified graphs, axial maps provide different information regarding the most integrated stairs, elevators, and corridors. Since it is impossible to assign a root line to the system of axial lines on DepthmapX, the metrics used to compare both models against the justified graph was integration, choice, and total depth on both global and local measures.

Figures 3 and 4 display that the axial lines with higher integration are related to S1 and E1. Figure 3, S1 remains as the staircase with higher integration and connectivity, but on the representation of Figure 4 of model 2, is showcased a different scenario of hierarchy, being E1 the one with more congestion over S1. Overall, the higher median axial lines are the ones that represent S1 and E1, according to the values of Table 3, 4 and 5, which is currently the most used set of vertical circulation.

Table 3: Metrics of axial lines representing stairs of model 1

Storey	ID	Choice	Choice R2	Integration [HH]	Integration [HH] R2	Total Depth	Total Depth R2
Basement	S1-1000	**2325**	2	**0.771**	1.658	**1119**	18
	S2-1000	463	**12**	0.592	**3.133**	1411	**16**
Ground Floor	S1-000	**4570**	**6**	**0.896**	**1.833**	**985**	15
	S2-000	575	2	0.628	1.658	1338	18
	S3-000	0	0	0.548	0.210	1511	**3**
	S4-000	1356	2	0.747	1.478	**1151**	14
First Floor	S1-100	**7233**	10	**1.032**	**2.312**	**876**	22
	S3-100	264	2	0.723	1.478	1183	14
	S4-100	2348	10	0.838	2.211	1042	**16**
Second Floor	S1-200	**8679**	6	**1.148**	1.958	**803**	19
	S3-200	493	6	0.779	1.774	1110	**13**
	S4-200	2998	6	0.914	2.196	969	27
Third Floor	S1-300	**10447**	6	**1.226**	2.139	**762**	25
	S3-300	369	2	0.814	1.658	1069	18
	S4-300	2628	**8**	0.962	**2.353**	928	24
	S5-300	2306	4	0.976	1.895	917	**17**
Fourth Floor	S1-400	13331	6	**1.247**	2.020	**752**	21
	S5-400	2360	6	1.009	**2.396**	892	26

Global measures of both models show consistency regarding this nucleus of S1/E1 as the primary evacuation route; however, when local measures are observed appears a discrepancy on stairs and elevators choice, between S3, S4 or E3.

Table 4: Metrics of axial lines of stairs and elevators of cluster 1, model 2

Storey	ID	Choice	Choice R2	Integra-tion [HH]	Integration [HH] R2	Total Depth	Total Depth R2
Basement	S1-1000	**85**	3	**0.926**	2.020	**1168**	**21**
	S2-1000	154	17	0.790	**3.926**	1337	27
	E1-1000	**2424**	16	**0.951**	**3.475**	**1142**	32
	E2-1000	325	12	0.806	3.208	1315	33
	E3-1000	179	6	0.775	2.524	1360	32
	E4-1000	985	**19**	0.852	3.848	1254	**29**
Ground Floor	S1-000	**572**	**7**	**1.096**	**2.439**	**1015**	28
	S2-000	61	4	0.768	2.139	1370	25
	S3-000	0	0	0.754	0.500	1393	**5**
	S4-000	1019	4	0.969	1.958	1124	19
	E1-000	**4859**	**14**	**1.132**	**3.218**	**989**	54
	E2-000	516	8	0.869	2.749	1233	33
	E3-000	416	6	0.880	2.081	1219	**23**
	E4-000	1796	10	0.985	2.762	1109	44

Through VGA analyses, there are slight differences in the change of pattern and behaviour of movement between the two models. In both scenarios, the visual cues of the escape route that remain as the primary one, S1 and E1, are within the occupants' visual field, making them an intuitive flow for the users.

Table 5: Metrics of axial lines of stairs and elevators of cluster 2, model 2

Storey	ID	Choice	Choice R2	Integra-tion [HH]	Integration [HH] R2	Total Depth	Total Depth R2
Ground Floor	S1-000	**572**	**7**	**1.096**	**2.439**	**1015**	28
	S2-000	61	4	0.768	2.139	1370	25
	S3-000	0	0	0.754	0.500	1393	**5**
	S4-000	1019	4	0.969	1.958	1124	19
	E1-000	**4859**	**14**	**1.132**	**3.218**	**989**	54
	E2-000	516	8	0.869	2.749	1233	33
	E3-000	416	6	0.880	2.081	1219	**23**
	E4-000	1796	10	0.985	2.762	1109	44
First Floor	S1-100	825	7	**1.152**	2.481	**975**	30
	S3-100	133	2	0.888	1.571	1210	**16**
	S4-100	**1667**	**14**	1.116	**2.635**	1000	25
	E1-100	**8144**	**46**	**1.332**	**3.860**	868	52
	E2-100	1261	9	1.239	2.749	**919**	33
	E3-100	490	2	0.956	1.273	1137	**10**
	E4-100	2690	22	1.132	3.249	989	41
Second Floor	S1-200	**1316**	8	**1.283**	2.481	**894**	30
	S3-200	290	6	0.963	1.833	1130	**15**
	S4-200	1130	**9**	1.132	**2.524**	989	32
	E1-200	**11076**	**35**	**1.510**	**3.587**	**787**	62
	E2-200	540	4	1.092	2.304	1018	31
	E3-200	993	6	1.094	2.020	1017	**21**
	E4-200	2815	18	1.253	3.193	911	52
Third Floor	S1-300	**1943**	**10**	**1.345**	2.524	**861**	32
	S3-300	246	2	0.997	1.740	1098	**20**
	S4-300	820	7	1.180	**2.688**	956	29
	S5-300	1007	6	1.156	2.353	972	24
	E1-300	**11956**	25	**1.595**	3.511	**755**	52
	E2-300	1191	**30**	1.139	3.499	984	30
	E3-300	302	2	0.960	1.163	1133	**8**
	E4-300	2691	**30**	1.313	**3.668**	878	43
Fourth Floor	S1-400	**2875**	8	**1.340**	2.396	864	**26**
	S5-400	1134	8	1.299	**2.749**	885	33
	E1-400	**14141**	**21**	**1.584**	**3.319**	**759**	49
	E2-400	601	6	1.094	2.647	1017	38
	E3-400	312	2	0.976	1.055	1118	**6**
	E4-400	1695	6	1.207	2.606	939	36

Figures 5 and 6 shows that, when compared against axial maps, between the basement and the third floor, the axial line with the highest integration also crosses spaces with higher visual integration, and the most segregated spaces are on the upper levels, as expected, where there is only one alternative of evacuation route. However, stairs and elevators on VGA do not have identical integration values to the axial lines that represent them as it can be seen in Figure 7, and this may be related to the limitations of the software and the way the floors are linked on the different analyses. While on VGA analyses, the connections are made with different grid cells for each convex space of stairs and lifts, it is possible to make more than one link to each axial line of axial maps.

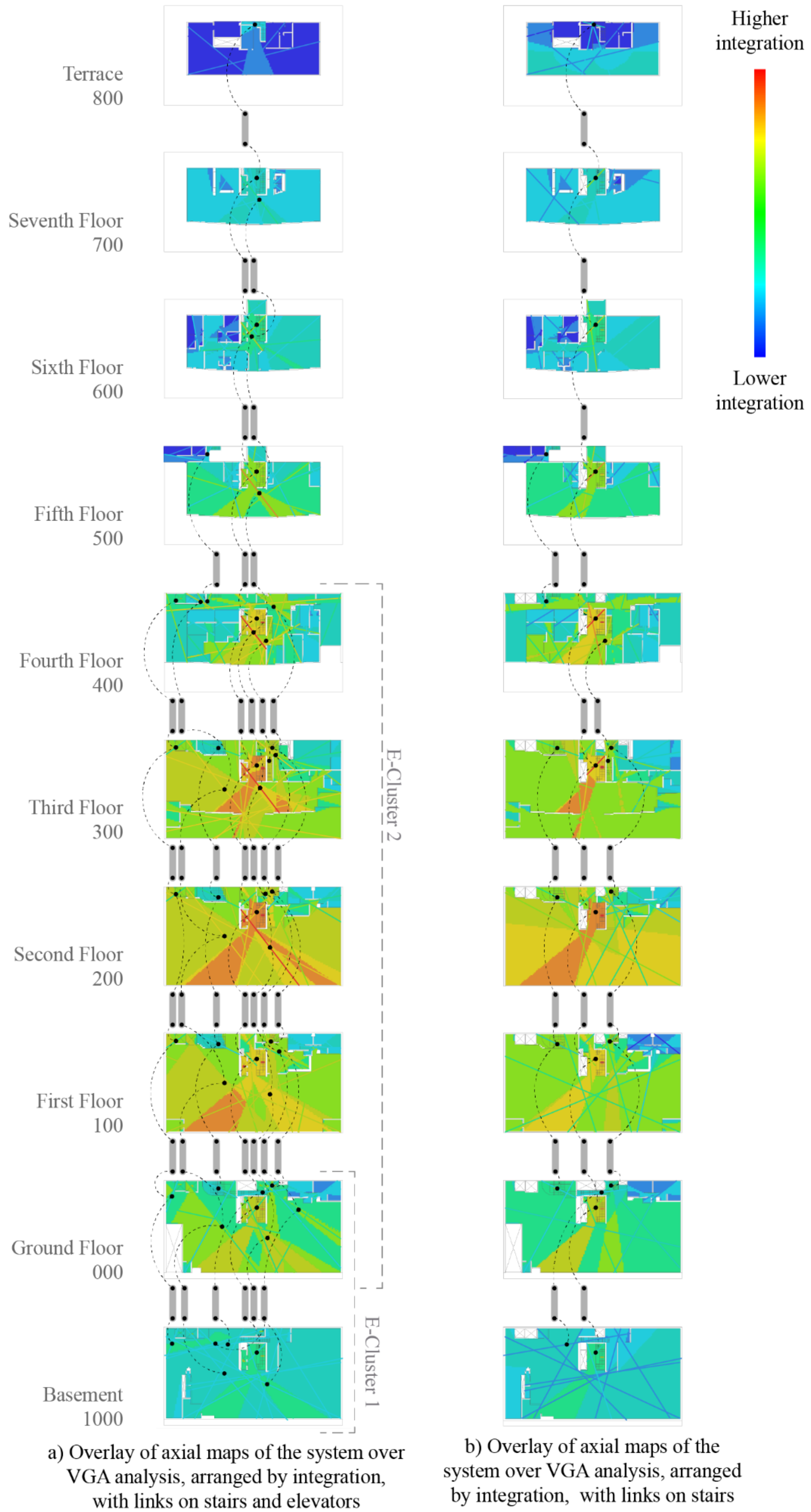

Figure 7: Juxtaposition of axial lines over VGA analysis, model 1 and 2

5 DISCUSS OF RESULTS

According to the methods of evacuation simulation, in the flow-movement modelling, the ideal escape route would be the shortest and most efficient in relation to the lesser time required to exit the building safely.

The information obtained from the spatial analysis demonstrates that, overall, the safest emergency route for escaping the building would be S1 and E1. This result was determined from the different space syntax analysis, being justified graphs the analysis that confirmed the assumptions made at the beginning of the study and was later verified by VGA analyses, which display that in the first, second and third floor, visual integration of E1 and S1 is evenly high in both models.

Nevertheless, axial maps demonstrate the opposite with the inclusion of elevators. The integration of the elevators is higher than the integration of the stairs, especially on the set of elevators and staircase 1, where E1, even though it does not link all the floors as S1, have higher integration values than S1. The axial line of the elevator with more congestion is E1 on the third floor, with integration values of 1.595 (seen Table 5), followed by the E1 of the fourth and second floors.

Similar discrepancies between axial maps and VGA, appeared on intermediate floors of the other staircases and elevators from the second to the fourth floor. These divergences might arise by the difference in the way the connections between floors are made and affects the results of the values of the analyses, hence the interpretation of why one analysis and the other do not correspond exactly.

It is important to notice that in relation to local measures of axial maps that can be appreciated on Tables 3 and 4, the clustering of landing spaces in the service area of the third floor where S4, S5 and E2 converge, the choice of a stair is not completely clear. For example, on local measures, S4 prevails over S1 on the third floor, and on global measures, S5 does the same on the third floor; while in Tables 1 and 2 of justified graphs appears that S5 is, along with S3, the least suitable stair for emergencies. Furthermore, compared to the integration and connectivity of axial maps, on model 2, while S4 earns relevance, S3 loses it, leading to contradictive information provided regarding the choice of primary and secondary escape routes, that justified graphs clearly show that the combination of E2 and S4, is the second stair and elevator with the highest integration of cluster 2. There is high congestion in this group of floors, and these local interpretations of the space could lead to an inefficient escape route that could lead to an ineffective evacuation of the building.

All the above comparisons confirm that cluster 2 on both models, where is a high concentration of alternatives of vertical navigation between floors, should be the target of assessment of whether this layout should be retained or not, and how not doing it is going to affect the way people perceives the vertical navigation of the building.

The current configuration might have had an advantage when the building worked as a casino in 1990 to have this level of segregation of groups and vertical circulation, but nowadays, it must be rethought and taken into consideration if this system works for future activities. The existing vertical navigation features within the building can be leveraged in future interventions if the design foresees maintaining the segregation of occupants, therefore the evacuees, by their function in the services and public areas. In this sense it is important to point out that inexperienced users of the building tend to travel through more visually connected and more visually integrated stairs or elevators, but perhaps these are less direct than those taken by experienced users (Hölscher et. al, 2009), that most likely will chose the routes they are familiar with (Nilufar & Choiti, 2019), and which is more possible to avoid inconveniences, thereby, ensuring efficiency of evacuation.

CONCLUSION

This study focused on the stairs and elevators of an existing building with multiple options of vertical transitions on its first fourth floors. Throughout the study was suggested which stairs and elevators could be used as the primary and secondary escape routes. The outcome of the prediction movement of evacuees is similar to the current performance of the building in normal conditions, and users of the building are most familiar with the identified escape route in its daily use. However, it would be necessary to carry on a real-life emergency simulation to compare the scape routes' performance since it might be influenced by the psychological behaviour of people and crowds during an evacuation event.

There are plenty of alternatives for evacuating the building on cluster 2; nevertheless, having multiple options does not necessarily is translated into high efficiency of evacuation since not all the stairs and elevators available lead to the shortest path to reaching the egress exit on the ground floor.

If the evacuation routes should be explored further, it would be interesting to compare the study results with an emergency simulation software because with existing space syntax tools is not possible to assign weights of extra data, such as time, distance, and gravity, to nodes within the system as it would be done with specialised software. Also, further work should be made regarding the definition of the interior and exterior convex spaces of this project, given that there are terraces on the third and eighth floors, that in the context of emergencies, could be used as evacuation spaces too.

AKNOWLEDGEMENTS

This work is financed by national funds through FCT - Fundação para a Ciência e a Tecnologia, I.P., under the Strategic Project with the references UIDB/04008/2020 and UIDP/04008/2020.

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