

Exploring isovist fields: A comparative study of churches in reconstruction plans for post-earthquake Lisbon

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Abstract. Following the Lisbon 1755 earthquake, Manuel da Maia (1677-1768), chief engineer of King D. José I (1714-1777), commissioned six plans for the city's reconstruction. We analyze these plans weighing how they addressed the challenges of building a modern city of the XVIII century. In them, churches had different roles in the urban morphology of the city. We investigate their interplay over the plans. The analysis of the importance of religious buildings in the city plan was made through the visual impact that those buildings had in the public space. Using isovists, we examine the visual impact of religious buildings on public space. Our results indicate that all plans, except the chosen one, promoted a greater visual impact of churches in public space. Plan 6 proposed a patriarchal church in *Terreiro do Paço*, with an extreme impact on the city's visual landscape. Conversely the chosen plan presented a similar visual impact of churches in the plan as the pre-1755 city. This resulted from the removal of churches from the main streets and their integration inside the city blocks. This plan presented a similar level of visual impact, comparable to the pre-1755, but with a completely different approach to the street drawing. Overall, this study sheds light on how different reconstruction options for the city of Lisbon could have impacted the city being rebuilt. The aftermath of the 1755 earthquake provided an opportunity not only to rebuild the city, but also to redefine the power balance within the kingdom and to shift the importance of the church as a central aspect of city life.

1 Introduction

Urban form evolution is a slow process, affected by the small-scale dynamics, and therefore the opportunities are scarce to promote radical transformations of the urban form. Large-scale planning occurs mainly in the cases of city expansion or in the cases of reconstruction due to catastrophic phenomena (earthquakes, volcanos, tsunamis). That is what happened in 1755 in Lisbon, where an earthquake of large magnitude followed by a tsunami devastated the country and mainly its capital, Lisbon. This created the scenario for a large-scale intervention for the city reconstruction.

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Using a variation of the isovist process, in the present text we examine the visual impact of religious buildings on public space, inherent to the proposed plans for the reconversion of the downtown of the Lisbon city in the aftermath of the 1755 earthquake.

There are two specificities of methodological contributions to this research. First, we highlight those who have carried out their research on the way of thinking the city through a historical, architectural, and urban perspective. This group includes França [1] who from a perspective of the history of Portuguese art contributed an innovative approach to updating the history of the city of Lisbon; Mullin, Rossa and Santos [2, 3, 4] who explain the urban project of Downtown Lisbon using urban cartography and the writings that accompany the plan, key data in the study of this city, and fundamental instruments for understanding it; and Sampayo [5] which proposes a method of evaluation and quantification of public space, measuring the different urban design options proposed for the construction of Baixa.

The second group refers to a group of authors who understand the city as a complex adaptive system, where different mathematical approaches make evidence for the structural properties of the urban form. Of particular interest are the works that take into consideration how the infrastructure is perceived by its user. How do salient features of the design impact symbolically the lives of the people in aspects as different as control, privacy, or defensibility. This aspect of space, and namely public space, has been a topic of interest for psychologists and architects and led to the creation of isovists and isovist fields by Benedikt [6]. The author defines an isovist as collection of points in space viewable from an advantage point and proposed measures to quantify size and shape of the resulting geometric figures. An isovist field is the set of these geometric figures [6].

Batty [7] develops a set of measures for isovist fields based on geometric measures grounded on distance, area, perimeter, compactness, and convexity, and argues that the classification of the isovist fields based on these measures, must be a requirement to the proper analysis of architectural and urban morphologies.

Turner [8] extends the notion of isovist, by showing that they can be used to generate a graph representation of mutual visibility between locations. This resulting graph can be achieved by other techniques as well and is called *visibility graph*. The use of a graph-based representation is argued to provide local and global characteristics conducting to the description of the city in terms of accessibility and visibility. These visibility graph representations can be compared across cities or alternative plans and are closely related to special perception, wayfinding, movement, and space-use.

In more recent year these approaches have been revised and discussed for their ontological and epistemological implications. Koch [9] focuses on the cognitive character that these graph-based approaches have acquired over years of usage and rethinks how space syntax, convex spaces or isovists can be perceived and if their representations still reflect the foundations on what they were formed on. For argument, isovists are constructed based on the notion of field of vision, but their resulting geometric object is something detached from the foundational concept. These discussions are of particular importance the ontological understanding of the syntactic analysis of cities.

2 Historical perspective

The 1755, November 1st earthquake that stroke the city of Lisbon [10], wasn't an isolated event in the city's history. Other catastrophes, equally violent, had occurred in the past, as was the case of the earthquake of 1531, January 26th [11]. The 1755 earthquake acted as a powerful transformation agent on the Lisbon transformation. It acted as a deciding catalyst in the growth of the illuminist ideas and its importance is such that Silva calls it "urban earthquake" [12].

The contrast between the before and after of the earthquake is very noteworthy. Lisbon public spaces are reformed according the emergent social and urban bourgeois values. The intelligent way how the city reacted to the terrible seism and its consequent developments, through a well thought urban plan, isn't resumed to a moment of inspiration, but to a methodical proposal that demonstrates and leverages the know how acquired through history [13, 14].

The XVII century showed a Portuguese Monarchy highly involved in regulating Lisbon urbanism. With D. João V (1689-1750) and D. José I (1714-1777) this process continued, and the urban image of the city improved.

With the earthquake, Sebastião José de Carvalho e Mello (1699-1782), the future Marquis of Pombal (1769- 1782), had the opportunity to stand and reinstate his political ideals. From the vast team, previous stated here, it was the chief-engineer of the kingdom, Manuel da Maia (1678-1768) who would have the strategic role in the tactical and technical definitions for the city reconstruction. The "Memory" dissertation that he presented, acted as a true program for the production of the final plan of downtown Lisbon (pre-plan of April 19th, 1756, and later the plan of Jun 12th 1758).

The dissertation of Manuel da Maya, besides being a descriptive memory of all the project hypothesis for the reconstruction of the downtown, is, also, a great example of early transfer of development rights. The dissertation of Manuel da Maya is divided in three parts, according to Sepúlveda [11]. The first two parts are at the Public Library of Évora and the third is at "Torre do Tombo" in Lisbon. There are some clues that a fourth part was planned but Manuel da Maya never wrote it. Manuel da Maya established five directions to the reconstruction of the city [11]:

1. Rebuild the city as it was before the earthquake.
2. Rebuild the city keeping the heights of the original buildings, but enlarging the widths of the streets, avoiding covered passages.
3. Rebuild the city diminishing the heights of the original buildings (to a maximum of two floors above the ground floor) and increasing the width of the narrower streets.
4. Rebuild the city by destroying what was left after the earthquake and redrawing the streets and height of the city in a "proper" way.
5. Abandon the city and build a new one in the Belém area (mostly unaffected by the earthquake).

After reflection on these hypothesis, Manuel da Maya presents on December 4, the first part of his dissertation for Lisbon reconstruction to the duke of Lafões, to the king, and finally to the Marquis of Pombal [1]. Although Manuel da Maya prefers the last hypothesis of changing the city to Belém, the final decision belonged to the king. The choice felt on the fourth alternative, keeping the city in the same place but starting from a "clean slate".

Although Manuel da Maya regrets the loss of his library with the earthquake, it is clear his knowledge of the reconstructions of other cities in Europe, as it was the case of London or even Turin: "Maia was inspired in his ideas by the revitalization of London after the Great Fire of 1666 and the plan for Turin developed for King Sarno by Ivvaro. What specifically he gained is unknown. It is known that Wren's plan for London, despite having been created in the previous century, addressed many of the problems now faced in Lisbon. It is also known that Pombal was familiar with London, having served as Portugal's ambassador to England. Concerning Turin, the concepts applied to that new city would have had direct application if the capital were relocated to Belém. The Turin plan called for building a new capital immediately adjacent to the old. However, neither example offered help in terms of addressing the personal hardships of the people." [2].

Walter Rossa agrees with the theory that Portugal had foreign influences that conditioned the drawing of the new Lisbon. He states that the relation of Lisbon with Turin and London

was not useful from the urban point of view but, according to the author, the references are mainly observed in the architecture nature of certain aspects of the city and prove them with the composition of the buildings of *Terreiro do Paço* [15, 16].

Manuel da Maya organizes, in the third part of his dissertation, different project teams with different objectives, as if they were in a public contest for the drawing of a plan for Lisbon reconstruction. He reunited six men of his trust, António Carlos Andreas (?-?), Elias Sebastião Poppe (1728-1778), Eugénio dos Santos de Carvalho (1711- 1760), Francisco Pinheiro da Cunha (?-?), Jozé Domingos Poppe (?-?) e Pedro Guatler da Fonseca (?-?) and defined teams for the drawing of several plans. He devised six plans in this way (from these, the plan number 5 is missing) [11]:

- For the plan No. 1 he selected Pedro Gualter da Foncêca and Francisco Pinheiro da Cunha;
- For the plan No. 2 he selected Elias Sebastião Poppe and is son Jozé Domingos Poppe;
- For the plan No. 3 he selected Eugénio dos Santos de Carvalho and António Carlos Andreas;
- For the plan No. 4 he selected Pedro Gualter de Foncêca;
- For the plan No. 5 he selected Eugénio dos Santos de Carvalho;
- and for the plan No. 6 Elias Sebastião Poppe was selected.

Manuel da Maya defined specific programs for the drawing of plans to be developed by each team. The first three plans had more restrictions in the program. They should respect the line forces of the old urban fabric. The latter three plans (4, 5 and 6) had more freedom. This conditioned the drawing of the former plans making the latter more regular.

Manuel da Maya had the clear notion how to build the city. First, the public building should be built and only afterwards should the residential ones be implanted [11]. Because of this, Manuel da Maya establishes two sets groups of plans for the reconstruction. In one set churches should be kept in the pre-1755 placements, while in the other set of plans he allowed the project leader to draw the churches wherever they felt fit.

In this sense, D. José I. continued the work of his father. The monumental Lisbon, as Rome, is put in evidence through the establishment of the power of churches proposed in the different plans by Maya. The papal Rome was built upon the ruins of the old Rome through a plan drawn by Sisto V in 1588 with the collaboration of the urban architect Domenico Fontana. This papal plan for the reconstruction of Rome had the objective to potentiate the mobility of the pilgrims between the seven main churches that would give them the indult. In this way, the church's location was strategic, and they should be very visible in the urban fabric [17].

In a careful reading of urban history, one notices that the implantation of public buildings is usually associated with important public spaces of the city. Making a survey over several cities it is possible to see that institutional buildings have an implantation logic, with many being placed in squares, at the end of important roads or in places of high visibility like topographic elevations [18].

From an historical perspective, one can also see that there are differences in the way these public buildings are positioned through time and its different concepts of the city. Comparing the renaissance and the baroque with the medieval period, one can see a significant change of attitude, mainly in what to perspective issues are concerned.

Benévolo, when referring himself to the European city of the XVI-XVIII centuries, states the search of adequacy of the city to the rules of perspective that were born in the Italian renaissance in the beginning of the XV century [17].

The exploration of perspective, through the placement of buildings or monuments, in the lines of the streets, or as focal points of squares, became a characteristic of the renaissance and baroque cities. In this new concept of city, the streets have the architectonic monument

as a background: With Bernini (1598-1680), the perspective is used to create dynamical spaces, which direct the eye to the great architectonic monument.

Since the location of the churches in the various plans for the lower part of Lisbon destroyed followed different criteria and how their presence in the urban network is extremely important, given that it catalyses different synergies, we consider it important to perceive the position of the churches in the urban network of the different planes. We analysed how the exploration of the perspective effect works, through the location of churches in the emptive of streets or focal points of squares, to understand which of the plans is closest to the characteristics of the Renaissance and Baroque city.

3 Work methodology

To carry out this study it was necessary to have access to the drawings related to the different proposals for the reconstruction of Baixa. Thus, several Portuguese archives were consulted with cartography of the period under study. The research in the Portuguese urban cartographic archives revealed the existence of several copies of the same plans with subtle differences [5].

In the “Gabinete de Estudos Arqueológicos da Engenharia Militar” (GEAEM) there are four plans (although França [1] identified five during the 60s, meaning that one is missing): Plan 1, Plan 2, Plan 4 and Plan 6; In the City Museum there are the following plans: Plan 1, Plan 2, Plan 3 (two identical versions), Plan 4, Plan 6 and also the plan of downtown before the earthquake.

There were some problems to accomplish this study as the Plan 5 is missing and on the other hand there’s no registry of which of these plans was used in the third part of Manuel da Maya dissertation. The fact that plan 5 is missing is known to almost all the researchers that studied the post-earthquake Lisbon [1-5]. This fact is also noticed by Sampayo [5]. On the other hand, the duplicity of some of the other plans (like 3) has passed unnoticed throughout the years [5].

Comparing the different plans from different archives from GEAEM and the City Museum one can see differences in the copies. This is most evident in the Plan 2 where the central squares of the plan are drawn in one of the copies and missing from the other (the squares are present in the City Museum plan and missing from the GEAEM plan) [5].

These differences are also noticeable in the configuration of the plan’s legends, in the placement of the scale in the drawing and even in the colours used [5].

Because of these differences, we chose the plans in the City Museum as the base for this work. The plans were digitized and rescaled to allow the comparison of features between the 5 plans (1, 2, 3, 4 and 6). When superimposing the 5 plans, we noticed that there are small misplacements of common buildings, mainly in the Plan 2. This is possibly due to the different precision of the drawings at that time (when compared to modern age) and this is even put in evidence by Manuel da Maya when he advised that during the reconstruction, the plan and the place had to come together reconciled.

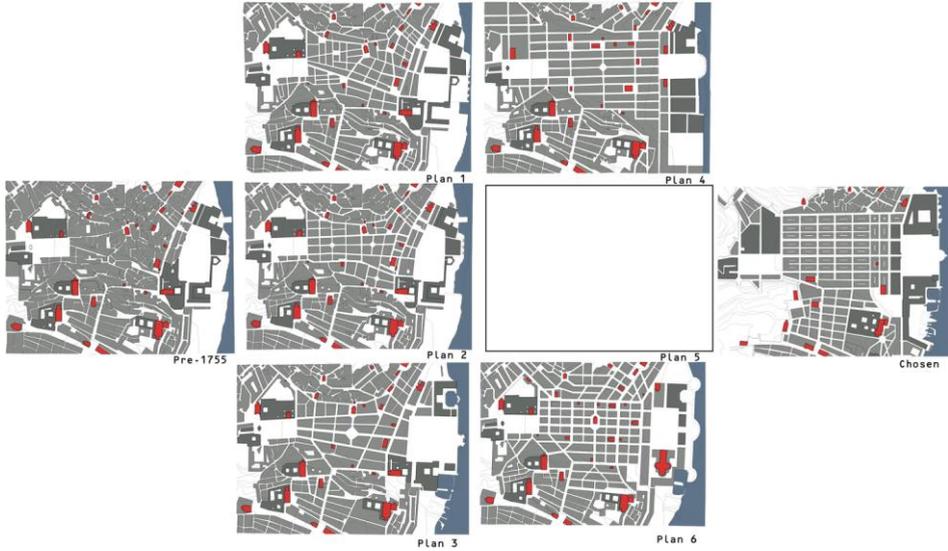


Fig. 1. Location of churches in the pre-1755 Lisbon, in the different known plans, and in the chosen plan for the reconstruction of Lisbon.

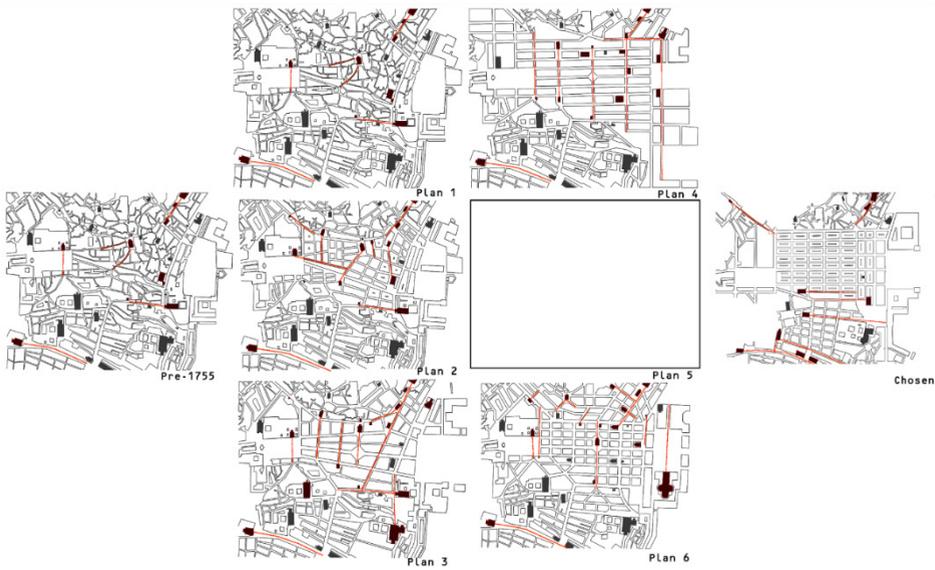


Fig. 2. Location of churches in the pre-1755 Lisbon, in the different known plans, and in the chosen plan for the reconstruction of Lisbon. Churches is done in the urban network emphasizing the perspective axes.

The analysis of the importance of religious buildings in the city plan was made through the visual impact that those buildings would have in the public space. It has been used a variation of the isovist process that allowed to ray trace the isovists as if the entire building was the focus of the raytracing. The main difference from traditional isovist creation is that instead of having a focus point, one considers the entire mass of the building of interest as being filled with focus for those isovists. This aspect is important as buildings present different facades and irregular shapes. Using the total mass of the building in the creation of the isovists allows for a complete understanding of the building in its surroundings.

4 Results of the analysis

Our analysis is first made by a direct observation of the placement of churches in the various planes (Fig. 1), trying to visualize whether the placement of churches is done in the urban network emphasizing the perspective axes of the streets (Fig. 2). On the other hand, we also tried to analyze the visual impact of the churches on the various planes through the construction of isovists for the churches (Fig. 3).

Table 1 shows that before the earthquake there were far more churches than were planned and rebuilt. The remarkable buildings, namely, the churches are structuring elements of the layouts. Analysing Fig. 2 we can see that in the various proposals of plans the churches usually form open spaces or squares. Analysing the location of the churches in the various planes, we can see that plans 1, 2 and 3 of 1756 do not present major changes in relation to what existed before the earthquake.

In the situation before the earthquake, the exploration of the perspective effect through the construction of churches is little used. In plan 1, there seems to be greater concern in exploring the perspective effect on churches. The perspectives in this plan are usually made for a corner of the main façade of the church. Plan 2 is not very rich in perspective effects using churches. However, plan 3 shows that it was designed to give importance to the perspective effect using churches.

Plan 4 makes use of the perspective effect, through the location of churches in the ends of the street axes, but similarly places churches in a situation parallel to the perspective axis. In this plan all the streets parallel to the river are spaces referenced by churches.

The chosen plan doesn't take advantage of the perspective by locating churches in the visual axes of streets. Instead, it is a plan with few churches. This plan makes an integration of the churches in the general proposal, not allowing their volumetric individualization at the level of street perception.

The logics of location of the remarkable buildings can structure the cities, but they also serve to guide people who roam the urban centres. From the analysis we conclude that some plans appear to have been designed giving importance to the effect of perspective, with the churches as a point of reference. The plan that presents more attention to the axial perspective in relation to the churches is plan 6. Comparing the post-earthquake proposals with the situation before 1755, it is observed that, before the earthquake, the church does not function as an organizer of the urban network, at the level of distanced references. The plans drawn up in the second half of the 18th century follow the rule of perspective.

The analysis of the churches impact in the public space was calculated through the occupied area of the visual cones via the modified isovist technique.

Table 1. The visual impact of churches in different plans

| | Visual impact | Total area | n. ° churches |
|----------|---------------|------------|---------------|
| Pre-1755 | 30% | 11% | 25 |
| Plan 1 | 46% | 20% | 22 |
| Plan 2 | 42% | 19% | 26 |
| Plan 3 | 52% | 19% | 24 |
| Plan 4 | 51% | 20% | 26 |
| Plan 5 | - | - | - |
| Plan 6 | 65% | 25% | 28 |
| Chosen | 31% | 8% | 15 |

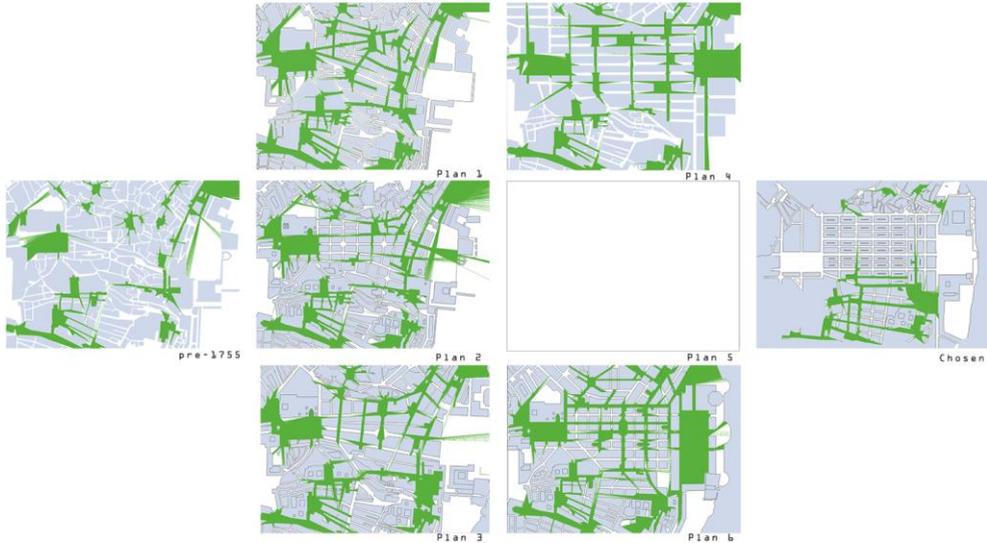


Fig. 3. The isovist constructions for the religious buildings of Lisbon for the different plans as also for the pre-1755 city

These results show that all plans, except the chosen one, had a greater visual impact of churches in public space. This was due to the placement of those churches combined with larger rectilinear streets. In plan 6 this influence was taken to extreme with the proposal of a patriarchal church in *Terreiro do Paço*. In the opposite direction the chosen plan shows a similar visual impact of churches in the plan as the pre-1755 city. This was accomplished through the removal of all churches from the main streets and integrating them inside the city blocks. This plan presented a similar level of visual impact, comparable to the pre-1755, but with a completely different approach to the street drawing.

5 Conclusion

This study showed how the different options for the reconstruction of the city of Lisbon would have impacted the city being rebuilt. We confirmed that a paradigm shifts in the drawing of the city through the historical analysis. The aftermath of the 1755 earthquake, allowed for the total reconstruct of the city and through that to restate the power balance in the kingdom. The new city changed importance of the church as a central aspect of its living. As observed through the historical analysis, the city model of the medieval city is different from the renaissance and baroque city. The placement of churches assumes a different role in each of those views.

All traditional architecture establishes a fundamental difference between the concepts of public and/or sacred buildings on the one hand and utilitarian and/or private buildings on the other. The former represents collective institutions, dignity, solemnity, grandiosity; the latter should be of an unpretentious level, they house private activities and housing. Thus, churches play a very important role in structuring the urban nuclei of the traditional city.

The logics of location of the remarkable buildings can structure the cities, but they also serve to guide people who roam the urban centres. It was determined that some plans show to have been designed giving importance to the effect of perspective, with the churches as a point of reference. The plan that presents higher consideration for axial perspective in relation to the churches is plan 6. Comparing the post-earthquake proposals with the situation before 1755, it is observed that, before the earthquake, the church does not function as an organizer

of the urban network, at the level of distanced references. The plans drawn up in the second half of the 18th century follow the rule of perspective.

This was confirmed in the simulation by the determination of the visual impact of the churches in the public space. The percentage of the visual impact shown in TABLE 1 denotes a difference between the old city and the new one. All the plans showed a greater visual impact of the religious buildings, except for the chosen plan. It seems, in accordance with Mullin (1992), that the church and the state were equal in power. The option between the chosen plan and plan 6, represented the choice between giving more power to the church (as for example via the proposed patriarchal church in *Terreiro do Paço*) or the control of the church by the state, making the role of churches less important. The Marquis of Pombal clearly wished to restrain the Church (Pombal expelled the Jesuits, for example). The chosen plan allowed him, at least symbolically, to precisely do that.

It is expected that, with this study, the importance of churches in the construction of traditional cities has been emphasized and that, together with other studies within this scope, we have contributed to this theme being more valued in the study of urban form.

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