VALUE GENERATION AND ITS RELATION WITH THE DESIGN PROCESS

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ABSTRACT

Some incorporators/developers, in order to have a feedback of their projects, have resorted to satisfaction evaluations. However, the data collected have not been systematically used in the feedback of management processes for new designs. The literature shows the importance of incorporating these data. Thus, the designers can generate more value to the final client.

This research has hypothesized the possibility of decision supporting tools - e.g. AHP, AD, TRIZ and QFD - to be used in a theoretical model which helps to process the data collected in satisfaction evaluations, aiming at the process improvement and at the value generation.

The qualitative research was divided into three methodological steps: the analysis of the tools, the adaptation of these tools and the test of the model. Through a pre-test and a focus group, the preliminary versions of the model were refined and the theoretical model was proposed.

KEY WORDS

Tools, Design, Feedback, Value.

INTRODUCTION

Intending to have a feedback from the final client of projects that have already been delivered, some incorporators/developers have resorted to satisfaction evaluations. In this sense, a series of researches related to clients' satisfaction have been developed in order to comprehend their needs (Egemen; Mohamed, 2006; Tang et Al, 2004; Torbica; Stroh, 2001).

While the literature shows the importance of incorporating data derived from satisfaction evaluations in new designs (Ornstein, 2008), one may observe that the data collected have not been systematically used in the feedback of these processes.

Besides, the design has a great importance on the entire life cycle of the products, including their construction and use. The initial steps, such as the architectural program, are important to the process as a whole. Moreira & Kowaltowski (2009) emphasize that, prior to the design, the architectural program starts with a survey of information related to the clients and to the context. The program also intends to describe the conditions under which the design will operate and the problem that the designed edification must solve. Tilley (2005) points out that the architectural design should be flexible and dynamic, and therefore, should be available for changes that may occur throughout the design process and the construction of edifications, because the clients' needs may also change over time. Thus, circumstantial changes are likely to bring more value to the client.

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The aims of the design processes consist in satisfying and engendering greater value to the client through a continuous improvement. Furthermore, these objectives relate to the principles of the new philosophy of production (Womack; Jones, 1998).

Planning to enable the incorporation of the clients' needs in a systematic way, as well as to help in the exploratory activities of the initial steps of the project, some decision supporting tools can be used - e.g. analytic hierarchy process (AHP); axiomatic design (AD); theory of inventive problem solving (TRIZ); quality function deployment (QFD).

This research, therefore, has hypothesized the possibility of decision supporting tools to be used in an integrated way and from the simplification of their use in a theoretical model that helps to process the data collected in satisfaction evaluations, aiming at facilitating the use of the results by the designers responsible for the conceptions of projects, improving this process, giving a feedback to the productive chain and enabling the value generation to the final client.

THEORETICAL REFERENCES

DESIGN PROCESS

According to Tilley (2005), the design process is a mental activity that has as product documented ideas in physical or electronic ways. The latter ones facilitate the communication of others who are involved in the design. The design, in turn, must follow some steps - from the architectural program to the execution project.

One may verify that this process demands interaction and commitment among a group of stakeholders, which includes the client, the final clients, the designers, the entrepreneurs, the suppliers and others (Kärna; Junnonen, 2005). Thus, the nature of the design process can be considered complex.

In this sense, Whelton & Ballard (2002) highlight some problems that influence negatively the design process, as the lack of sharing the made decisions, the socio-political factors that dominate the decision makings and the inefficient processing of information. Koskela et al (2002) also point to the inexistence of a systematic design planning and the ineffective management of the value from the client's point of view.

According to Venkatachalam et al (2009), the use of the principles of lean production in the design process can correct any defects related to this process and give due importance to the edification process.

DECISION SUPPORTING TOOLS

This item presents the decision supporting tools - AHP, AD, TRIZ and QFD -, which were mentioned in the introduction of this article and used in the model proposed. AHP is a multicriteria method for decision making (MCDM). It uses a methodology of quantitative comparison that helps to verify the relation between qualitative alternatives, and thus to define the importance that each one has. It also helps to describe how a solution, in particular, reaches and meets the primary objective of the problem (Gass, 1985). Thus, AHP has the capacity to turn the selection, ordering and judgement processes into transparent ones. This tool also permits that the system of weight attribution makes the problem more manageable.

About AD, it was originally developed to help designers of Mechanical Engineering to identify existing problems in design processes, which generated inferior solutions (Monice; Petreche, 2004). The use of the tool is based on the assumption that there are generalizable principles that define the design process, which begins with the recognition of a need. The design question, therefore, based on

AD, is defined in considering two basic questions: "what do we - clients and designers - want" and "how are we going to get it" (Monice; Petreche, 2004). According to Yang & Zhang (2000), AD helps to eliminate trials and errors from the conventional design process and also helps the designers to structure and comprehend the design problems better.

TRIZ was idealized by Altshuller from the analysis of the processes involved in obtaining creative solutions contained in patents, from which regularities were found and from which principles and laws were defined, as well as this theory (Carvalho; Back, 2001). This tool is associated to the stimulation of creative activities, consisting in the restructuration of a specific design problem into a generic one, which has consolidated referential principles as a solution. From all the methodologies that compose this tool, the most known relates to the method of inventive principles. They are based on forty inventive principles that represent suggestions for possible solutions to a specific problem (Carvalho; Back, 2001). Thus, this tool helps designers and inventors in the conception process of products, avoiding the conventional method, based on expertise and on trials and errors, solving the problems in a creative way (Yang; Zhang, 2000).

Finally, QFD is a project tool originally produced in a Mitsubishi ship factory (Hauser; Clausing, 1988) that started to be used by automobile industries with the goal to increase the levels of the clients' satisfaction. According to Delgado Hernandez et al (2007), the main objective of this tool consists in helping to identify and to prioritize the clients' needs and to transform them into product features. This tool is composed by four matrices, that deploy clients' needs into design requirements. The design requirements originate the features of the component, which are transformed into manufacturing operations and define the product requirements (Eureka; Ryan, 1992). Therefore this tool is directly associated with the value generation, because they help to transform the clients' needs into design attributes, according to Kamara et al (1999).

METHODOLOGY

This is a qualitative and exploratory research, because the data were collected in a natural environment and the investigation aims at a careful analysis of a not very discussed subject in the literature - the use of decision supporting tools in the context of the feedback of the design process.

Furthermore this is eminently a bibliographic research, which converged on the proposition of a theoretical model of help to the feedback of the design process. A field survey was then started with researchers from the civil construction management, with architects and civil engineers to investigate the application process of the first versions of the model. For this purpose, a pre-test and a focus group were performed, respectively. At the end an overall analysis was carried out and the final theoretical model was proposed.

This research consists of three methodological steps which meet its objectives. In the first one, the decision supporting tools were analyzed. In the second, these tools were adapted to specificities of the civil construction, in order to systematize the feedback of the design process. Finally, in the third stage, the theoretical model of help to the feedback of the design process was tested.

TOOLS ANALYSIS

From a general review of the literature, the AHP, AD, QFD and TRIZ tools were chosen to compose the model according to the characteristics of each. First of all, AHP helps to determine the prioritization among alternatives. AD and QFD assist in the deployment of the clients' needs into design features. They also manage the trade-offs that may occur along this process. Besides, TRIZ suggests possibilities for design solutions.

It was verified that the positive aspects of these tools have an association to eight of the eleven principles of the lean construction, which are consistent with the value generation. Despite each positive aspect has been associated, with great emphasis, with a principle of the lean construction, one may check that the same positive aspect may be associated with different principles. However, Chart 1 demonstrates the main association made between the positive aspects and the principles. In this sense, three of these principles are associated with the four tools - reduction of the share of activities that do not add value to the product, increase of the transparency of the process, and focused control on the global process.

Some aspects are associated with the principle of reducing the share of activities that do not add value to the product, such as the identification of inaccurate information since the beginning of the process, the reduction of late changes and of trials and errors of the traditional design process. About the transparency of conflicting solutions, the creation of a data bank and the knowledge transfer are related to the principle of increasing the transparency of the process. Finally, the aspects of a better communication are presented, as well as the formation of multidisciplinary teams and the hierarchy of the design, which are related to the principle of focused control on the global process.

Concerning the principles of increasing the product value through considering the clients' needs, of the reduction of the variability and of the cycle time, it is important to say that they are associated with the use of QFD. On the other hand, the principle of increasing the output flexibility is related to AHP, AD and TRIZ. About the principle of introducing a continuous improvement in the process, it refers to the use of AD.

ADAPTATION OF THE TOOLS

Once the theoretical model behaves as a help to the feedback, it is presumed that the data that must be inserted in the process refer to the clients' needs that were considered unsatisfactory. Thus, they must be transformed into new design parameters, which will be incorporated in the process of developing new products. The use of the tools, therefore, is associated with this condition.

One may verify that AHP, among the multicriteria supporting methods for the decision making, is the most suitable one for the theoretical model proposed, because it enables the paired comparison between alternatives due to specific criteria defined by the evaluators. Therefore, this tool can help in the prioritization of clients' needs or of the design parameters, which consist in the two data analyzed in the theoretical model.

		POSITIVE ASPECTS			
		AHP	**AD**	**TRIZ**	**QFD**
RELATED PRINCIPLES	**Reduction of the share of the activity parts that do not add value to the product**	General analysis of the design problem	Identification of the inaccurate information since the beginning of the project	Reduction of the trials and errors of the traditional design process	Reduction of the late change associated with the design process
			Reduction of the trials and errors of the traditional design process	Identification and resolution of the contradictions	Identification of the bottlenecks
			Identification of the design problem		
	Increase of the product value through considering the clients' needs				Increase of the client's satisfaction
					Help in collecting and identifying clients' needs
					Translation of clients' needs into design requirements
	Variability reduction				Reduction of uncertainty
	Cycle time reduction				Time Reduction of product development
	Increase of the output flexibility	Versatility	Carrying out the design process in a creative way	Resolving the design problems in a creative way	
	Increase of the transparency of the process	Transparency of the selection, ordering and judgement processes	Data bank formation	Transparency of conflicting solutions	Transparency between the clients' needs and the design requirements
		Describing how a solution satisfies the objective of the design process	Solutions for the clients' needs		Data bank / documentation formation
		Trade-off management	Trade-off management		Knowledge transfer
		Paired comparison of the solutions			
	Focused control on the global process	Formation of multidisciplinary teams	Considering the design process question	Verifying the resources that can be used	Formation of multidisciplinary teams
		A better communication	Structuration and comprehension of the design problem		A better communication
		Incorporating qualitative and quantitative values	Structuration and mapping of the design process		Planning
		Simultaneous consideration of various criteria	Design process hierarchization		A more effective resource allocation
		Management of the design problem	Possibility of analyzing the design consistence		Cost reduction
	Continuous improvement		Designer's experience		

Chart 1. Relation between the positive aspects and the lean construction principles (Source: primary data).

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About the domains that compose AD, only the process one is excluded, since it has a closer relation with the production. Thus, the client domain is considered, because it corresponds to their needs; the functional domain as well, because it corresponds to the functional requirements which respond to these needs; and also the physical domain, which refers to the design parameters that satisfy the previous requirements.

About QFD, the house of quality matrix was considered the object of the analysis of the theoretical model proposed, once it is related to the first steps of the design process. The other steps, on the other hand, refer to the stages of production. In the house of quality, it was important to verify the existent interferences between the clients' needs and the requirements of the design.

And about TRIZ, one may verify that the theoretical model can make use of the inventive principles in a direct way from the correspondence between these principles and the design parameters to be proposed.

PROPOSITION OF THE MODEL

In order to reach the proposition of the theoretical model, two preliminary versions of the model were developed, i. e., there was a refinement of the model until its third and final version, as it can be seen in the Figure 1.

The first version was submitted to a pre-test with researchers and carried out after the adaptation of the tools. The main changes refer to the exclusion of TRIZ, because of the time spent in the knowledge about the inventive principles. They also refer to the inversion of the third and the fourth steps, on one hand, due to the importance of considering all the design parameters and, on the other hand, of prioritizing the unsatisfactory needs when they exist in a large number.

Then the second version was developed from the criticism done during the pre-test. This version was applied to two focus groups composed by architects and civil engineers. The satisfaction evaluation used in this case was conducted in the context of social housing. At the end of the application process of the model, the designers were brought together, and a final discussion about the model was raised.

Based on the analysis of the second version of the model, one may verify that the proposed model can be applied to the cases of public housing projects. However, it is necessary to investigate the applicability of the model in other contexts. Besides, although the model has emphasized a parameter of quality, it proved to be deficient in considering the financial aspect.

Regarding the application of the model, one may notice that it is important to pay attention to the elected criteria for prioritizing the unsatisfactory needs. The participants of the focus group highlighted that some of these needs were not related to the architectural design itself.

At last, the importance of the discussion among the various individuals involved in the product development process was enhanced, in order to reach a consensus. The importance of the feedback was also emphasized, because it reinforces the need of researches that can contribute to this purpose.

The third and final version of the model was proposed after the focus group (Figure 2). As the others, this one consists of five steps to be performed in a sequence. They may generate a systematized discussion about the clients' needs from the first steps of the design process.

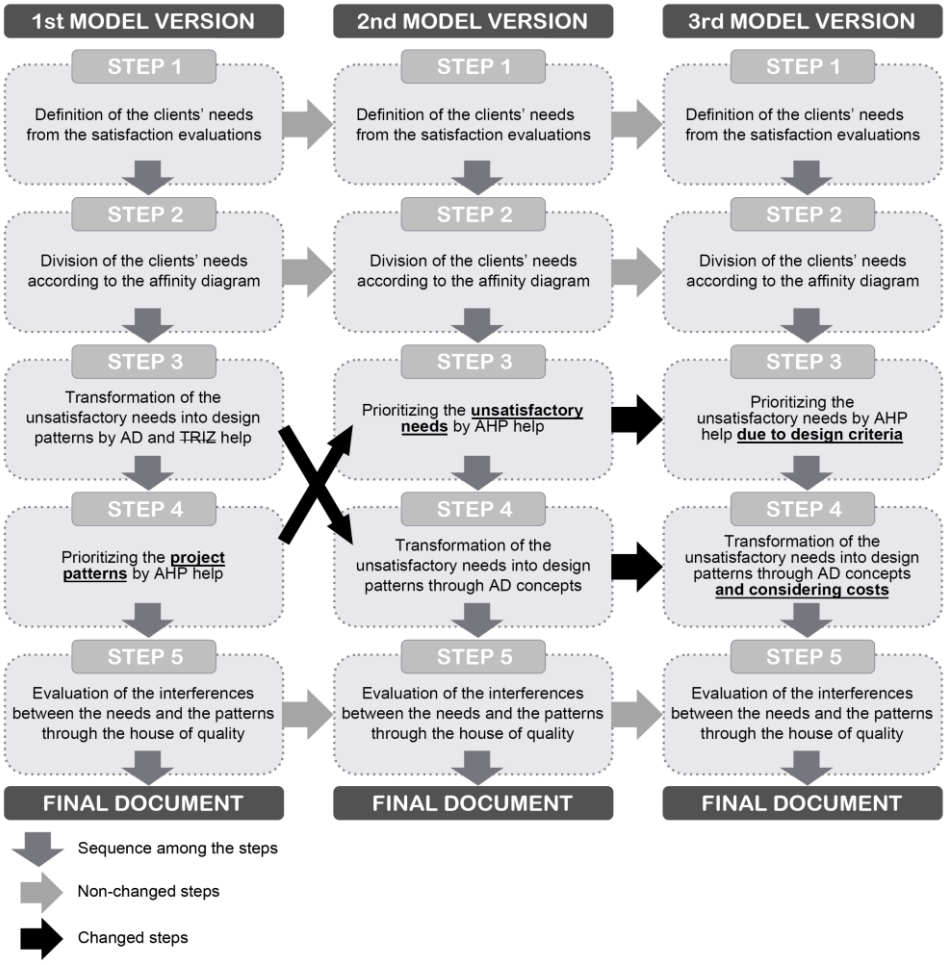

Figure 1. Relation among the three versions of the model (Source: primary data).

In the **first step**, the clients' needs were defined from the results of satisfaction evaluations conducted in edifications with a similar typology of the new planned building. The needs were listed and the satisfaction level was indicated. From this purpose, the criterion for classifying the needs was defined in unsatisfactory, neutral and satisfactory, and the needs were classified.

In the **second step**, the clients' needs were divided into primary, secondary and tertiary by the affinity diagram. The cards were grouped according to the existent affinity among them, and an affinity card was incorporated into each group (secondary needs). At last, all the cards were attached on a sheet and the affinity groups were gathered in broader ones, which were one more time renamed (primary needs).

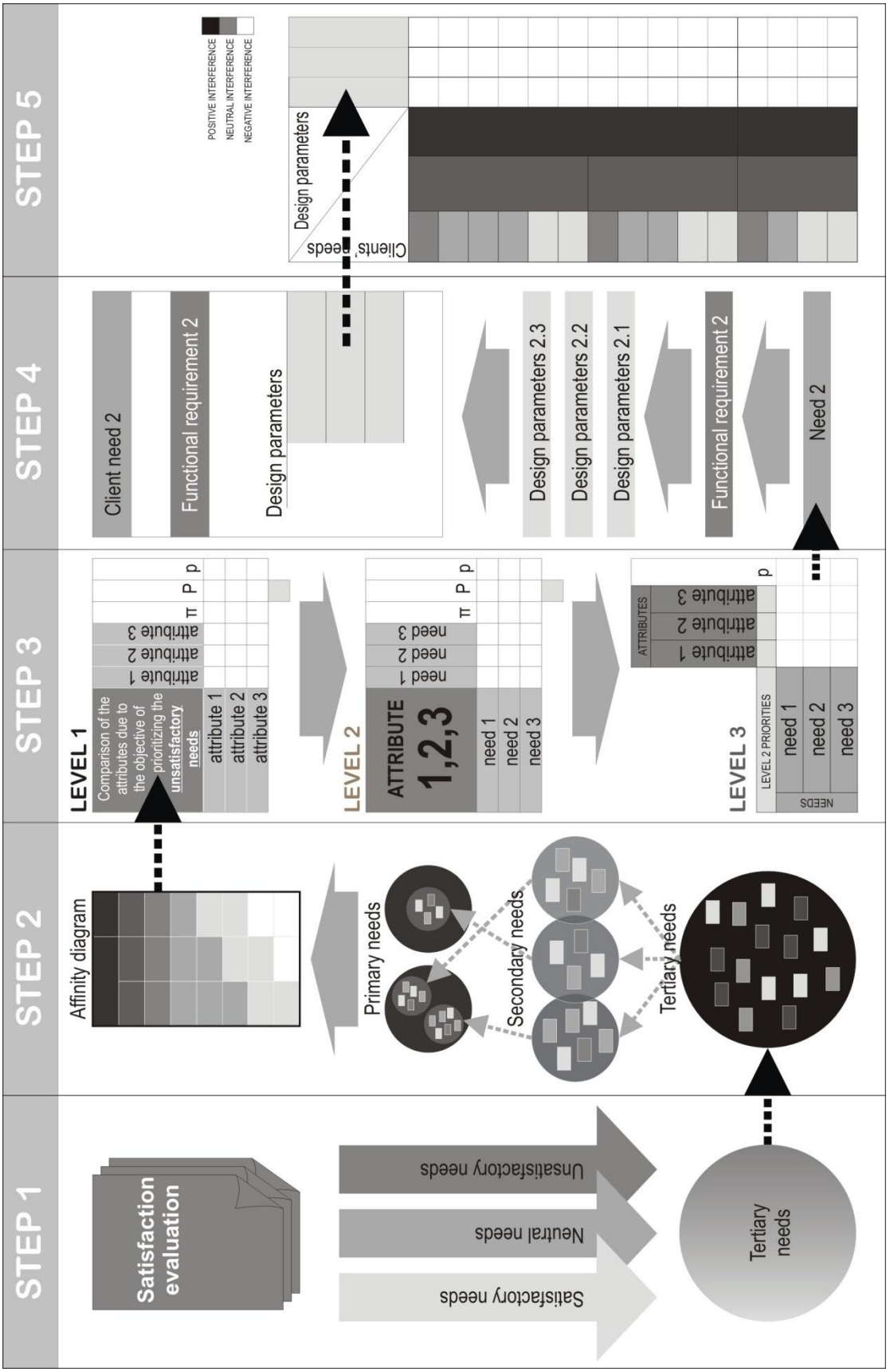

Figure 2. Relation among the five steps of the third version of the model (Source: primary data).

In the **third step**, the unsatisfactory needs were prioritized with the help of AHP. The designers had to elect which would be the attributes of prioritization. At the first level of analysis, the attributes were compared to each other to verify the relation among them. At the second level, the unsatisfactory needs were compared to each other due to each attribute. And at the third level, the needs were compared with the attributes. The result defines the prioritization of needs.

In turn, in the **fourth step**, the unsatisfactory needs were transformed into design parameters through concepts of AD. For each need a functional requirement was established, which represented what had to be done, and the parameter means how it should be done. The definitions of the parameters occurred by the indication of solutions by the designers and through reaching an agreement. At last, specific forms were filled out for each need.

Finally, in the **fifth step**, the positive, negative and neutral interferences between the clients' needs and the design parameters were evaluated through the house of quality (QFD), which was filled with the design parameters defined in the fourth step and with the needs that compose the affinity diagram (second step).

CONCLUSIONS

This research began with the investigation of the lack of a systematic processing of the data collected in satisfaction evaluations, in order to support the design process. This lack was checked through a literature review and through the confirmation that the evaluation results are informally passed on. However, it is important to use these data systematically in the process of new designs. Thus, future projects can satisfy the final clients more.

One may also verify that the design-construction-use sequence should not be a linear procedure, starting at a determined point and finishing at another one. It should be a continuous cycle, in which the design step should have a feedback from the use step. Thus, the generation of value is not exhausted in a unique sequence, because it can be improved through new experiences. Once the incorporator/developer uses the feedback as a practical, the final clients tend to be more satisfied. Therefore, the search for a continuous improvement must become an essential objective of these incorporators.

Regarding the academic contributions, this research discusses the possibility of a systematic feedback of the design process from the data collected in satisfaction evaluations. This subject was not very discussed in the literature so far. At last, the model proposed can be used in practice by companies which have interest in using satisfaction evaluations in order to give a feedback to processes of new designs with similar typological features. That is why this research is considered as having a technical contribution. Theseway, the hypothesis was confirmed.

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