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# Quality Function Deployment Methodology for Evaluating Customer Satisfaction in Mass Housing Sector

Yeliz Olcay
*Istanbul Technical University, Institute of Science and Technology*
*Building Sciences Programme, Istanbul, Turkey*
*yelizin@superonline.com*

## Abstract
Along with the concept of globalization, the competition among the world markets has become stronger and as a result, customer satisfaction has become the most important way for companies to differentiate themselves from their competitors. Thus, the companies must accurately determine the customers' needs and requirements in order to achieve perfect and permanent customer satisfaction. Supposing that the performance of a mass-housing producer could be evaluated by customer satisfaction, it is explored what percentage of the customers' needs and expectations has been concerned and adapted in accordance with today's mass housing trends. With the guidance of this evaluation, the applicability of the Quality Function Deployment (QFD) methodology to mass housing sector has been questioned and a sample model has been proposed for its adaptation to the sector. Within the context of this study, an attempt has been made to contribute to developments pertaining to the adaptation of QFD to the construction industry. For this purpose, a strategic focus group representing the potential mass housing customers has been composed and a research has been carried out with this group to collect and process data concerning their basic requirements and expectations. The finding of the study has demonstrated that the companies in the mass housing production market can considerably benefit from this methodology. As a result, despite some limitations and challenges, QFD has been observed as a very flexible and adoptable tool for mass housing producers, while evaluating the expectations of their potential customers.

## Keywords
Quality function deployment, Customer satisfaction, Mass housing sector

## 1. Introduction

Total Quality Management (TQM) is a management philosophy which requires continual improvement of all the processes and the outcomes within an organization. The aim of TQM is certainly to reach a kind of business excellence and since the customer is the one who rates the quality, customer satisfaction is undoubtedly comes out to be the key concept of TQM. However, before obtaining the absolute customer satisfaction, it is essential to understand the requirements and expectations of customers. Because of the complex nature of the construction process and the unique characteristics of the industry, it is quite difficult to determine the customers' needs and expectations accurately. Simply, when companies know which attributes of a service or product affect customer satisfaction, their challenge is to modify their current service/product in a way that would lead to maximum customer satisfaction (Karna, 2004). According to today's business trends, customer satisfaction is the key factor of quality, and customers are the ones who determine and rate the quality. Therefore, construction companies must adopt customer focused systems to evaluate the customers' requirements and to transform these requirements into the production process.

Quality Function Deployment (QFD) is a planning methodology of TQM for transforming the customers' needs and requirements through the production processes into the completed facility. In this research, a case study has been conducted by which, the steps of the QFD process are followed

and the House of Quality (HOQ) chart has been developed. The focus and the findings of this study are limited to the mass housing sector, however the concepts of the proposed model could be implemented to the other sectors of the construction industry.

## 2. QFD Methodology

QFD is a matrix based methodology, which is used to translate the customers' quality needs into design requirements and to change these requirements into critical product and process features. It is a highly effective and structured planning tool to deal with customer demands more systematically and defining what they want precisely to do it right in the first time (Dikmen *et al.*, 2004). The main principles of QFD methodology include the following: (1) To define the quality in terms of customer requirements and satisfaction; (2) To evaluate the customer expectations and the use of charts and matrices to propagate critical customer requirements throughout the product development life cycle; and (3) To attach numeric values to the customer requirements to determine the levels of importance (Kamara *et al.*, 1999).

QFD concept was first introduced in Japan in 1972 at Mitsubishi Heavy Industries Kobe shipyards by Y. Akao. In United States, the methodology was first used in 1986 by Ford and Xerox companies (Yayla, 1998). Right after, a great attention has been drawn to QFD and it has been consecutively used by important companies like Hewlett-Packard, Digital Equipment and Texas Instruments (Kagnicioglu, 2002). Later, the method has become common in manufacturing industry, but it was still not implemented in the construction industry untill recent years. The reasons for the small number of QFD applications in building construction are various. Such impeding factors could be, for example, the one-of-a-kind nature of projects, the large number of participants (designers, contractors and suppliers) or lack of knowledge about the methodology (Laurikka *et al.*, 1997).

Despite the mentioned difficulties and constraints, QFD application presents considerable benefits. While it can be basically used as a management tool, it can also be used as a continuous improvement tool, a requirements advisor, a translation tool or a decision support tool. The potential benefits of QFD can be summarized as follows: (1) a structured methodology to identify the customer needs and expectations; (2) reduced uncertainty as the project phases develop; (3) better coordination and collaboration between the parties; (4) better planning of activities from the start till the end of the project; (5) enhanced quality in the end product; (6) increased customer satisfaction; (7) increased competitiveness and market share for the company; (8) reduced total project budget; (9) decreased design and production periods; (10) reduced budget for facility management; and (11) retrieval and reuse of project data in further applications (Yayla, 1998; Dikmen *et al.*, 2004; Kamara *et al.*, 1999).

## 3. Application of QFD in Construction

The construction literature is quite limited in terms of the number of QFD applications and the number of examples in this category is even fewer, due to the unawareness of the sector participants about this technique (Dikmen *et al.*, 2004). Concerning the application of QFD to construction, the following areas were thought to be the best targets: (1) strategic planning; (2) project programming (setting objectives and quality requirements for a project); (3) innovative design of a building sub-system; and (4) product development (developing new materials, components, etc.) (Laurikka *et al*., 1997). While Mallon and Mulligan (1993) used QFD on a hypothetical renovation of a computer workroom facility, Armacost *et al*. (1994) applied QFD to integrate the customer's requirements in an industrialized housing component: a manufactured exterior structural wall panel (Gargione, 1999). Laurikka *et al.* (1997) used QFD in co-operation with a structural design firm and two contractors in three construction projects, whereas it has been utilized by Serpell and Wagner (1997) to determine the preferences on the design characteristics of the internal layout of a building apartment (Dikmen *et al.*, 2004). Gargione (1999) used QFD in the design phase of an apartment construction project; Eldin and Hikle (2003) implemented QFD process in the development of the conceptual design for a modern large-size college classroom; and Dikmen *et al*. (2004) applied QFD as a strategic decision making tool after the

construction stage of a housing project to determine the best marketing strategy. Based on the literature review, it can be stated that QFD is a very flexible tool and it is applicable to the construction industry in different ways.

## 4. Case Study: QFD Application in Mass Housing Sector

Supposing that mass house production is the most similar type of building construction to the industrial type serial production; it is claimed that mass housing sector can propose a suitable practice platform for QFD adaptations to construction. Consequently, a suggestion has been proposed for the implementation of QFD in mass housing sector and a case study has been driven by which the basic customer expectations and requirements have been associated with the mass house producers' main activities and operations of the project process.

Since the study targets mass housing sector, the refered customer is at the same time supposed to be the end-user of the completed product. Taking in consideration the diversity of the customer profile in the mass housing sector, the focus of the study is limited to the middle and high income people and the companies which are producing housing areas with social facilities to target this customer profile. The main aims of this QFD exercise could be stated as follows:

1. To provide a systematic procedure to guide the companies in decision making and project planning during all the processes of the projects including the inception, design, construction, use and disposal.
2. To present a tool for the mass housing producers to define the potential customers in the very beginning of the project, for example in the early inception phase, and to determine that pre-determined potential group's expectations and needs.
3. To obtain a complemental approach for associating the customer needs and expectations with the every stage of the total project life cycle.
4. To suggest a weapon to the mass housing producers for differentiating themselves in the market and for creating competitive advantage.
5. To present a sample exercise for the researchers who might study on the subject and for the companies who might adopt the methodology

Within the case study, the "main and common" expectations of the focus group are associated with the "main and common" project stages of the mass housing producers, which will be specified in the following sections of the paper. The HOQ chart used in this study is derived from the literature search and adopted accordingly with the needs of the study (Figure 1). Additional information can be found in Eldin and Hikle (2003), Inceoglu (2004) and Yayla (1998) concerning the QFD implementation and the formulation steps of the HOQ chart.

### 4.1 Contractor Side of the Study and the Data Collected From the Companies

In Turkey, Istanbul as the focus of this study, it is questioned how much the customers' needs and expectations has been concerned and adapted in mass housing production. Detailed interviews have been made with four different design and construction companies which produce a huge amount of housing units for the Turkish housing market every year. The names of the companies are withheld due to the principle of confidentiality. The interviews have been made with the authorized employees and managers of the companies to define the existent situation of the sector in terms of customer orientation and to identify the limitations of the current practice.

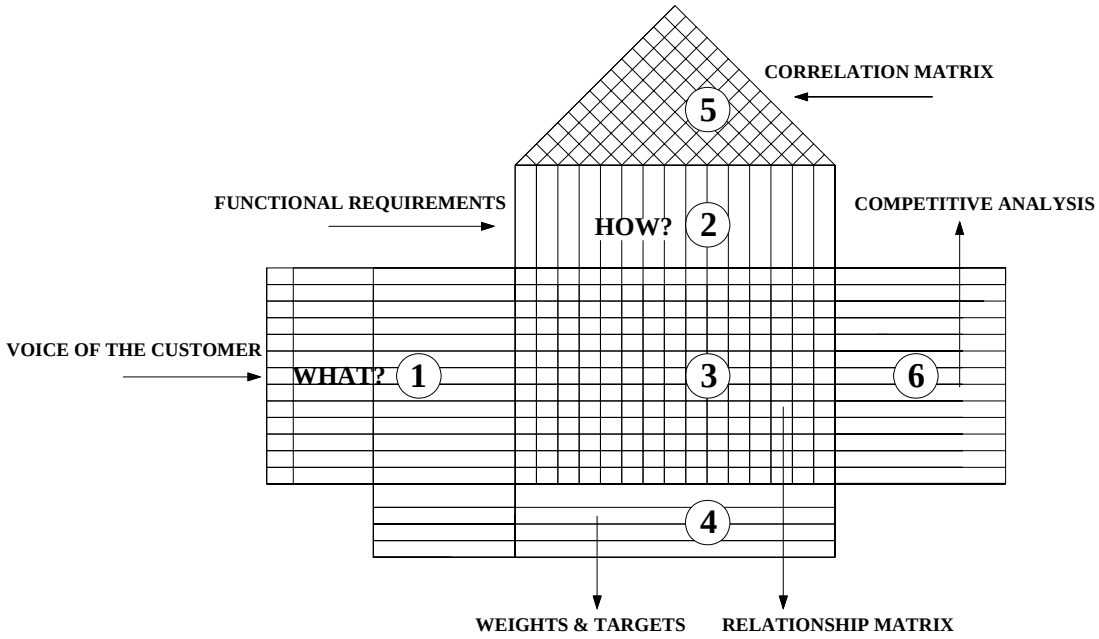


**Figure 1: Main Sections of the House of Quality (HOQ) Matrix**

All four companies produce minimum 1000 housing units every year, and they are all specialized in mass housing production. The companies spend a considerable effort to understand their potential customers. All of them try to determine their target group during the early phases of the project and collect data from the potential customers via questionnaires and market surveys. The questionnares are evaluated by statistical methods from time to time, and are called upon as a reference. However, the collected data is not been clarified and filtered to define the criteria of the "voice of the customer". A structured analysis investigating the relationships of this data with the operational phases of the project is not done. Because of this reason, the information regarding customer expectations cannot be integrated to processes or to end products. In this context, the QFD model proposed within the study is perceived as an effective and practicle tool by the companies. It is declared by the companies that the suggested matrix methodology might fill in an important gap.

### 4.2 Composing the Focus Group

The first step in constructing the HOQ chart is to determine the voice of the customer, which is basically a realistic list of the expectations and requirements of the potential group. Focus groups represent a data collection procedure in which a group of individuals identifies the expectations, perceptions, feelings and thinking pattern of consumers regarding a product, service, or an opportunity (Eldin and Hikle, 2003).

In accordance with the data collected from the producers, a research area has been selected and a focus group has been composed from the existing customers of the companies who are at the same time the residents of the selected research area. The research area contains 7500 housing units in total, which consists of three regions, each produced by different companies and company partnerships. The area contains social facilities and open area for recreational purposes as well as the housing units in high rise buildings targeting middle and high income people. The reason for selecting this area is that the companies managed all the stages of the projects including planning, design, construction, and even selling to the end users and this matches with the "total life cycle approach" of the study. The focus group has been formed with the intention to represent the potential mass housing customers. The participants of the focus group have been selected randomly from the pre-determined research area. All of the 20 participants are tenants in the housing area produced by the interviewed companies and they do not know each other prior to the QFD implementation. The strategic reason of selecting tenants is that they represent both the current users and also the potential buyers of the future; so the data provided from these participants is thought to be multi-dimensional. Within the context of the

research carried out with this group, the data concerning the basic requirements and expectations has been collected and the voice of the customer has been stated.

### 4.3 Developing the Horizontal Section of the Matrix – Voice of the Customer

The survey, which is conducted with the focus group, consists of two parts. In the first part, the participants are asked to list the general expectations and requirements regarding to the ideal house in their minds, which they could be willing to buy. When preparing this list of expectations, the priorities are not taken in consideration and each and every stated requirement is noted freely.

Afterwards, the data collected from the focus group is organized by using affinity diagrams and the voice of the customer is defined as presented in Table 1. The listed items are not based on their priorities and the effort thus far is spent only to identify the "main and common" expectations of the customer.

**Table 1: Voice of the Customer**

| | |
|---|---|
| Location | Easy access to public transport, closeness to city center, neighbourhood, closeness to shopping |
| Favourable Price | Price, payment conditions |
| Quick Delivery | Short waiting period after the payment untill the delivery of the housing unit |
| Earthquake Safety | Earthquake resistance, stability, materials, standards |
| Size | Size of the housing units, variety of housing types (1+1, 2+1, etc.) |
| Functionality | Area usage, architectural layout, all the subjects concerning the bathrooms, kitchens, storage areas, cupboards, cabinets, immobile furnishing, etc. |
| Aesthetics | Subjects concerning the appereance of the housing units, and the housing area |
| HVAC & Energy | All the technical subjects concerning the electricity, heating, water, etc. |
| Service | Facility management, service provided to the residents, maintenance and repair, etc. |
| Car Park | Adequate open and closed parking area |
| Security | Subjects concerning the security |
| Social Facilities | Sports facilities, recreational areas, play areas, green areas, etc. |

In the second part of the survey with the focus group, the participants are asked to rate the determined expectations and requirements according to their personal priorities. The weight/importance level of each customer requirement is calculated according to the ratings of the participants. The relative weight of each customer requirement is also calculated and all the data is recorded on the matrix.

### 4.4 Developing the Vertical Section of the Matrix – Functional Requirements

In general, functional requirements consist of technical solutions corresponding to the customer expectations and are defined by the QFD team of the implementing company which is developed to conduct the QFD practice. However, in this study, the identified functional requirements consist of the common operational steps of the mass house producers to meet the customer needs and expectations. Because, it is the aim of the author to associate the customer expectations with the project phases in order to adapt QFD to mass housing sector as a kind of highlighter of the critical processes to maximize the overall satisfaction. These functional requirements constitute the vertical section of the matrix and are defined as a result of advanced literature survey in addition to the detailed interviews made with the companies.

Determined functional requirements are as follows: (1) land selection; (2) feasibility study; (3) work schedule; (4) soil investigation; (5) specifying the project requirements; (6) architectural design; (7) construction drawings and technical details; (8) technical specifications and conformance to quality standards; (9) supplier election and subcontractor organization; (10) professional project management; (11) required permits and official documents; (12) delivery; (13) facility management; (14) service throughout the operation phase; (15) last step of total life cycle: demolition.

### 4.5 Relationship Matrix

Relationship matrix indicates the impacts of each functional requirement on every customer requirement. With the guidance of this evaluation, the contribution of each functional requirement in

overall customer satisfaction is discovered. This section is filled subjectively by the author depending on the appertaining literature survey and the data obtained from the companies during the interviews. The relationships between the functional requirements and the customer expectations are visualized by symbols. All of the relationships are shown in Figure 2. The valuation scale and the explanation of the corresponding symbols are indicated in Figure 3.

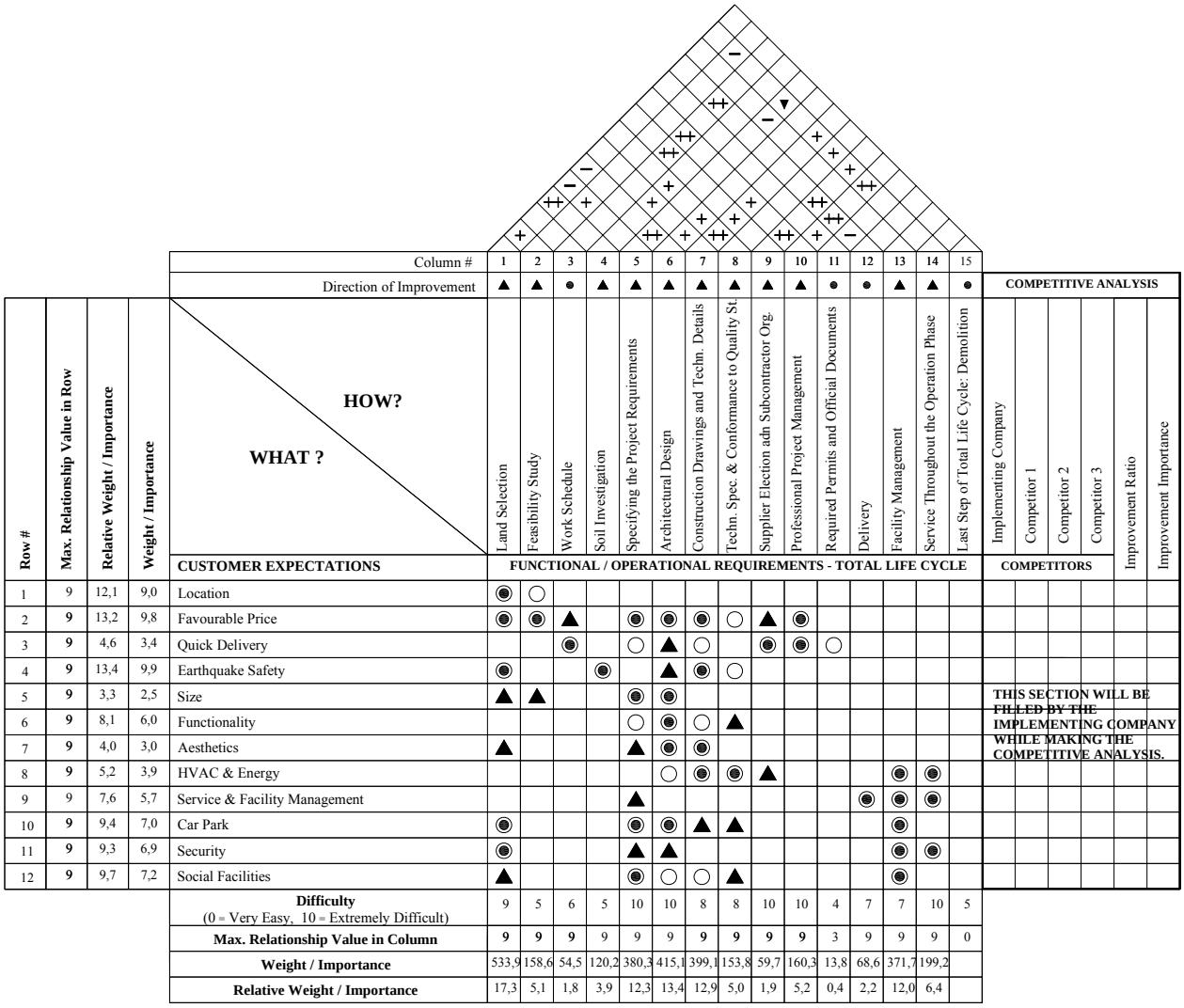


**Figure 2: House of Quality (HOQ) Matrix Developed for Mass Housing Sector**

The absolute weight/importance level of each functional requirement is calculated according to the relative weights of the customer expectations and the degrees of relationships on the corresponding row. The absolute weights of the functional requirements are calculated by multiplying the relative weight of every customer requirement with the relationship value on the same row and adding them for each coloumn. Subsequently, the relative weight of each functional requirement is also calculated and all the data is recorded on the matrix (Figure 2).

**LIST OF SYMBOLS**

| Symbols of the Relationship Matrix | | | Symbols of the Correlation Matrix | | Symbols of the Direction of Improv. | |
|---|---|---|---|---|---|---|
| ◉ | Strong Relationship | 9 | ++ | Strong Positive Correlation | ▲ | Maximize |
| ○ | Moderate Relationship | 3 | + | Positive Correlation | ▼ | Minimize |
| ▲ | Weak Relationship | 1 | — | Negative Correlation | ● | Target |
| | | | ▽ | Strong Negative Correlation | | |

**Figure 3: List of Symbols of the HOQ Matrix**

After these calculations, every company should rate the difficulty levels of the functional requirements from 0 to 10 subjectively. The difficulty level of a functional requirement means the complexity of achievement for the company considering the sectoral conditions, as well as the company resources and limitations. After this rating is completed, the direction of improvement is determined for every functional requirement considering the relationship between the importance and the difficulty level of the corresponding requirement. The direction of improvement row gives information concerning the need of improvements for the operational processes.

### 4.6 Correlation Matrix

The interactions between the functional requirements are investigated and the roof of the matrix is filled considering this information. These interactions are also visualized by symbols of which the explanations are indicated in Figure 2.

HOQ matrix also enables the companies to compete with the rivals by making detailed benchmarking surveys. The competitive analysis section located on the right side of the matrix is assigned for this purpose. The company performance on meeting each customer expectation is compared with the competitors and by this way the improvement requiring customer expectations are investigated and the goals are set for the future. In this case study, the competitive analysis section is left blank; because the developed matrix is an adaptation attempt of the methodology for mass housing sector to constitute a precedent for the companies. This specific company related information is required to be filled by the implementing company.

## 5. Findings of the Case Study

The HOQ matrix in Figure 2 actually presents a visual chart of all the outputs of the study. When the developed HOQ matrix is examined column-wise, the importance of each functional requirement can be seen as well as its contribution in the overall customer satisfaction. Similarly, if the matrix is dealed row-wise, every customer expectation can be investigated in terms of its relationships with each functional requirement. The impact of every functional requirement in satisfying a specific customer expectation can be observed clearly. Row-wise investigation also introduces the customer expectations which are linked with the highest number of functional requirements.

According to this case study driven for the mass housing sector, three most important customer expectations came up to be ‘earthquake safety’, ‘favourable price’, and ‘location’. Depending on these most overrating expectations, ‘land selection’, ‘architectural design’, ‘construction drawings and technical details’, ‘specifying the project requirements’ and ‘facility management’ appeared to be the most important functional requirements depending on their relationships with these expectations. By this way, the most critical operational phases have been stated to obtain the maximization of the overall customer satisfaction. A visual map is developed in order to concentrate on the processes which respond more to the customer expectations and requirements. The participants from different disciplines are enabled to coordinate and to share a common vision of customer focus from the very beginning of the total life cycle of the project.

## 6. Conclusions

In this study, an attempt has been made for the adaptation of QFD methodology to the mass housing sector. A sample implementation has been made to question the applicability of the methodology and to constitute a precedent for the mass house producer which might eventually like to use QFD. It is important to understand that the developed matrix within the case study presents a system approach and a decision making/planning tool. That is the reason why the producers need to concentrate on the methodology of the study instead of the content of this sample matrix. The content of the horizontal and vertical sections of the matrix should be composed once again for every application. Within this application, the customer expectations have been interacted with the phases of project to enable an analysis in terms of the principle of "total life cycle". Reasonably, the satisfaction of the customer expectations and requirements is related with the operational steps of the cycle.

It should be taken in consideration that the case study has been driven with the participation of the companies and customers which are located in Istanbul, Turkey. QFD methodology is peculiar to project and one of its major characteristics is its flexibility in terms of scope and contents. Consequently, the results of the matrix will vary for each particular practice. The geographical conditions of the country, the economical situations of the moment, the direction of technological developments, and the various special aspects will certainly affect the results of the later implementations.

However, it has been predicated that QFD methodology is adoptable to the mass housing sector and the companies could benefit by using it as a strategical planning tool to become more customer focused. As the approach assuming the quality "in the eye of the customer" is accepted more in the construction sector, it is anticipated that QFD methodology will become widespread and the number of implementations will increase.

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