

PROMOTING GOOD DESIGN MANAGEMENT PRACTICES IN COLOMBIAN CONSTRUCTION PROJECTS

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Managing the design of Architectural/Engineering/Construction (AEC) projects has usually been portrayed as a complex activity by many recent international research articles. Despite of the increased worldwide interest, there have not been found any design management investigation in Colombia. Thus, the main objective of this on-going study is to generate a conceptual design-management framework for a local engineering design firm. The study has been divided in two stages, diagnosis and implementation, and only the diagnosis phase is reported in this document. This stage includes an analysis of the particular design processes set by the company, establishing good practices, highlighting areas of improvement, and proposing recommendations. The research was conducted through two case studies. It has been found that this particular design firm has implemented good practices in terms of establishing long-term relationships with some of its clients, and developed a knowledge management information system. However, supply chain integration, client requirements management, risk management, and constructability reviews are the major suggested areas of improvement. As a consequence, it is clear that the main barrier to overcome these design difficulties, is the interaction with the external corporate environment. Therefore, the design-management framework proposed is based on recommendations directed towards creating multidisciplinary design teams and promoting a better relationship with clients and final users.

Keywords: conceptual framework, design management, engineering consultancy.

INTRODUCTION

In the construction industry, the design process can be defined as a set of complex problem-solving procedures in which ideas and concepts are creatively transformed into models, drawings, and specifications through carrying out both technical and managerial operations (Austin *et al.* 2007; Freire and Alarcon 2002). Since many specialists participate in such process and each one of them has its own set of interests, its management usually requires significant co-ordination, commitment, and adaptability within an uncertain and fast-changing environment (Formoso *et al.*, 1998).

Over the last years, there has been a growing academic and industrial interest in design management (DM). Among others, on the academic side, there have been several studies regarding collaboration (e.g.: Austin *et al.*, 2007), improvement guidelines (e.g.: Azambuja and Formoso 2003), and planning (e.g.: Freire and Alarcon 2002). On the other hand, different task force studies (e.g.: The Egan and Latham, Report in the UK; and the Integrated Project Delivery Guide in the US) demonstrate

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that there is a rising concern about increasing the design process performance within the construction industry.

Despite of the recent relevance given to DM, such topic has not been properly discussed in any academic/industrial/governmental study in Colombia. Although the Colombian Construction Chamber and the Colombian Infrastructure Chamber have highlighted the importance of increasing the industry's competitiveness, these efforts have not considered the design process. As a result, this study seeks to be one of the first steps towards implementing a DM culture within the country.

The research has been developed through two case studies in one of the major Colombian engineering consulting firms. The Company provides design-related services in areas such as electrical energy, water and sanitation, transportation infrastructure, urban development, industrial facilities, etc. However, although the Company is recognised as one of the leading organisations at the national level, its managerial processes still involve reworks, adversarial relationships, and difficulties in identifying and mitigating project risks. Consequently, it is argued that the proper application of DM concepts may assist the firm to perform critical tasks consistently and met business targets successfully.

Since it is extremely risky for any organisation to implement new managerial methods without doing an adequate examination of its own processes, this paper aims to develop a managerial diagnosis based on DM concepts. The diagnosis includes establishing good practices, highlighting areas of improvement, and formulating recommendations. In order to examine the firm, best practices have been extracted from the literature and grouped into eight major categories. Once categorised, they have helped to analyse the case studies and formulate a DM framework to enhance design processes in the Company.

LITERATURE REVIEW: DM CONCEPTS

The review served to identify a framework of topics required to analyse DM practices within the Company. The search was focused on theoretical, questionnaire-based and case study-oriented investigations. Theoretical investigations (e.g.: Austin *et al.*, 2007; Anvuur and Kumaraswamy 2007) provided a general understanding of DM concepts. Questionnaire-based investigations (e.g.: Chan *et al.* 2001; Chan *et al.* 2004; Eriksson 2008) allowed to comprehend how some DM ideas were seen and applied in different construction industries worldwide. Case studies (e.g.: Azambuja and Formoso, 2003; Freire and Alarcon, 2002) supplied practical examples of some DM practices. Based on the review, seventy-five DM practices were identified (Figure 1).

At the same time, exploratory interviews were held in order to examine the Company's DM maturity. It was established that although the firm had good internal attributes (i.e.: good-quality products, trust among designers, good information system), it had difficulties in dealing with the external environment (i.e.: clients, suppliers, contractors). Interviews confirmed that the Company has experienced common design problems that are suitable to be analysed against related literature.

Issues reported in the exploratory interviews were compared to the seventy-five DM practices identified previously (Figure 1) . It was decided to clasify practices into eight conceptual groups, using DM definitions, similarities/differences among practices, data collection strategy, and opinions from the Company's management personnel. Each conceptual category corresponds to a particular DM topic, and are briefly described below.

Supply Chain Management

For the purposes of this study, it is assumed that a design process can be managed in the same way a manufacturing firm controls its network of goods/services providers. In construction, a design chain is defined as a project-specific group that deals with intermittent information flows (Austin *et al.*, 2007). Therefore, its administration depends on achieving good levels of willingness and commitment among all the design chain members (Azambuja and Formoso, 2003).

Client Requirements Management

The management of client requirements involves a set of procedures directed towards defining and dealing with external (i.e.: owners and end users) and internal customers needs (i.e.: design project participants) (Freire and Alarcon, 2002). Successful DM teams manage client requirements diminishing uncertainty during design, in a systematic way (Sheng and Liu, 2003). Good practices in this area entail procedures such as an adequate information flow, early owner involvement, change-management systems, etc (Kamara *et al.*, 2000).

Communication

Design is a process that requires an efficient communication system due to its dynamic nature (Hegazy *et al.*, 2001). In this study, communication practices are specified as procedures intended to increase and operate the contact/control points among project participants (Chan *et al.* 2004), and to improve information flow inside the organisation (Freire and Alarcon, 2003). Both mechanisms should be supported by an appropriate change management system (Hegazy *et al.* 2001).

Contracts (Project Procurement)

Good contractual practices, as defined for this investigation, seek to highlight the importance of selecting procurement procedures that promote collaboration and fair agreements. Contracts should specify project's objectives and establish clear roles and responsibilities for every participant (Anvuur and Kumaraswamy, 2007; Chan *et al.*, 2001). Procurement models should be systematic, and include aspects such as cost, quality, expertise, etc (Eriksson, 2008).

Quality

For this category, good practices include tools and techniques that may increase quality in design. Freire and Alarcon (2002) recommend checklists and process maps implementation. Lam *et al.* (2008) explain the benefits of applying training programs for designers, technological innovations and value management techniques. Finally, Chan *et al.* (2004) propose periodic performance assessments and control mechanisms focused on key performance indicators.

Constructability

Fisher *et al.* (2000) suggest that it is not easy to undertake constructability analysis in construction design because contractual arrangements do not usually include constructability-related clauses. Based on that, good practices in this topic include hiring external consultants, receiving prompt feedback from construction personnel (Arditi *et al.* 2002), the use of standardised designs, the implementation of value engineering techniques, and the development of a lessons learned database (Arditi *et al.* 2002; Fisher *et al.* 2000), among others.

Risk Management

Kumaraswamy *et al.* (2005) argue that risk identification should take place through integrating project participants. Chan *et al.* (2004) suggest that risk management plans should be collectively developed in order to achieve win-win agreements among project actors. Moreover, these plans should help to specify mitigation strategies in order to implement adequate control mechanisms. Therefore, good design practices in this area should be directed towards getting an increased integration and familiarising designers with risk management issues.

Trust

The concept of trust is pivotal to ensure a timely and accurate data exchange in design procedures. However, building trust among project participants is not a simple task. According to Fong and Lung (2007), trust-related practices can be built through contracts, competition (i.e.: technical and managerial capabilities), or reputation. In addition, the establishment of long-term relationships also helps to create trust. Consequently, it is highly desirable to generate transparent interaction procedures and promote teamwork workshops in order to avoid adversarial environments.

RESEARCH METHODOLOGY

This study has been conducted through a multiple case study approach and has sought to answer the following question: what are the good practices and areas of improvement for the Company? A case study methodology has been selected because of the nature of the research question and the lack of control over contemporary events (Yin, 1994). Two consulting projects were chosen and analysed according to the following research framework:

1. Exploratory Interviews: several design projects were analysed as potential case studies. Two cases were selected based on the following criteria: first, they were the only projects in which the Company had performed a managerial role from conception to operation; second, they represented a special strategic value for the company; third, they were two of the most complex projects that the Company had ever managed; and fourth, they had a complete and up-to-date collection of archival documents.
2. Research Propositions: Each one of the seventy-five DM practices was considered as a research proposition (hypothesis) suitable to be tested against the cases' information
3. Archival Analysis: the archival information was considered as an empirically based pattern, suitable to be compared against the propositions (i.e.: theoretical patterns).
4. Semi-structured interviews: a twenty-five-query questionnaire was designed to test the validity of the pattern-matching exercise. Interviewees included personnel from the design company (i.e.: five management individuals and five designers), and external participants involved in the two case studies (i.e.: three management individuals per case).
5. Recommendations and workshop discussion: analysed data were presented to a group of five management people at the firm in order to classify each of the assumptions made, either as a good practice or as an area of improvement. Recommendations were presented in order to sustain good practices and bolster improvement areas.

CASE STUDY DESCRIPTIONS

The first case, hereafter project X, consisted in the design of a gas power plant. Traditionally, for this project type, the Company establishes an engineering-and-procurement contract that includes the design of electrical, structural, and civil systems (i.e.: conceptual, basic, and detailed solutions) and activities regarding selection, procurement, and installation of specialised equipment. However, despite of having participated in many other power plant projects, efficiency in design procedures has remained low and standardisation has not been possible.

The second case, hereafter project Y, was about designing and managing the construction of a new building for a renowned plant hire firm. The Company was in charge of doing the land-developing planning, designing the whole building, and managing the construction phase. This project was a big challenge for the Company in terms of dealing with high-levels of uncertainty (i.e.: client requirements management) and complexity (i.e.: design and construction management). Table 1 depicts key characteristics of the two case studies.

Table 1: Summary of key case study characteristics

| | Project X | Project Y |
|------------------|---|---|
| Project Duration | 3 months | 18 months |
| Project Location | Huila, Colombia | Medellin, Colombia |
| Project Cost | 250.000 USD | 1.000.000 USD |
| Project Type | Gas Power Plant for petroleum-related operations in an area of 19.200 Km ² | Industrial facilities for a plant-hire firm. 12000 m ² |
| Contract Type | Engineering and Procurement | Engineering, Procurement and Construction Management |
| Form of Analysis | Archival Analysis, Semi-structured interviews, Workshop discussion | |

GOOD PRACTICES AND AREAS OF IMPROVEMENT

Each case was analysed by focusing on DM concepts previously defined. A good practice was classified as such if observed both in project X and Y. In contrast, an area of improvement was identified as such in case of a lack of a good practice in at least one of the two analysed projects. This approach was adopted because it was considered that if a practice was not applied in both projects, it was neither fully developed nor consciously implemented within the organisation. Both the good practices and the areas of improvement are presented and analysed in Figure 1.

In Figure 1, a rectangular bar represents a DM concept. Each bar is divided in up to ten parts and every sub-division corresponds to one of the research propositions made. For example, the rectangle that represents the concept of supply chain management (S) has ten sections; each of them has been named as S1, S2, etc. Moreover, the bar location has been determined in accordance with its classification either as a good practice or as an area of improvement. For instance, a category such as constructability (B) is completely placed on the right-hand side because none of its practices are undertaken in the Company's projects.

Apart from showing and classifying the seventy-five good DM practices, Figure 1 also depicts the three general environments through which the Company develops its projects. The external environment represents those activities that involve high interaction levels between the Company and other firms (i.e: suppliers, subcontractors, clients, etc). The internal environment exemplifies those processes that can be carried out without major outer influences. The internal-external interface symbolises the

interaction between the two previously mentioned environments. Consequently, Figure 1 shows that the external environment comprises four design management concepts. The other four ideas are placed in the other two areas. The eight design conceptualisations are discussed as follows:

Constructability (B)

It is clear that constructability issues have not been properly considered in the Company. Archival documents and interviews showed that project participants (i.e.: client, designers, contractors) regarded constructability as a tough concept to be applied. However, all the participants pointed out that it is a topic that should start to be implemented. Although including constructability-related clauses in contracts or standardising design procedures might seem practices difficult to be applied, there are other techniques through which the firm can make significant contributions towards improving design performance. For instance: establishing predefined communication procedures or appointing an external consultant in order to enhance communication between the construction team and the design group.

Risk Management (K)

The Company develops risk management plans. However, these are not properly communicated. Archival evidence demonstrates that such plans are carried out at a top-managerial level and are not focused on project-related issues. Other project participants (i.e.: client, suppliers, contractors) either do the same or not undertake risk planning exercises. According to the authors' experience, this is not surprising, because there is not a risk-managing culture within the national construction industry. As a result, risk-related processes should become more transparent within the Company and take into account project specifications. Transparency can be promoted by conducting introductory workshops and developing a common risk database inside the firm. Analysing project details from a risk-management standpoint would allow project participants to make decisions by fully understanding their implications.

Client Requirements Management (R)

The Company is very good in dealing with its internal client requests because they are mostly based on technical issues. However, when it comes to understand external client requirements, the firm has many weaknesses. Interviewees have suggested that there are neither predefined protocols nor standardised templates for interacting with outer clients. For that reason, the Company highly relies on procedures set by outside customers. For example, in Project X, archival documents show that some legal aspects had not been properly assessed at the moment of deciding an expansion for the electrical facilities to be built. In project Y, written evidence suggests that the scope had not been clearly specified since the beginning. Some of the interviewees considered that clients were the main cause for such problems. However, if the Company wants to perform a leading role in the future, it needs to learn how to educate and interpret its clients' needs.

Supply Chain Management (S)

It was observed that contracts do not guarantee a timely and accurate information delivery among design chain members. For example, the supplier of an electric motor for Project X only provided the equipment specifications at the end of the design phase. Moreover, reworks in Project Y were also registered due to untimely and incomplete data. In both cases, it was evident that the Company did not perform its DM leading role as required. The organisation was only focused on delivering good-

quality design products regardless of the cost and/or time allocated. In order to improve its DM performance, the firm should motivate collaborative bidding processes, information-sharing mechanisms, and multidisciplinary workshops.

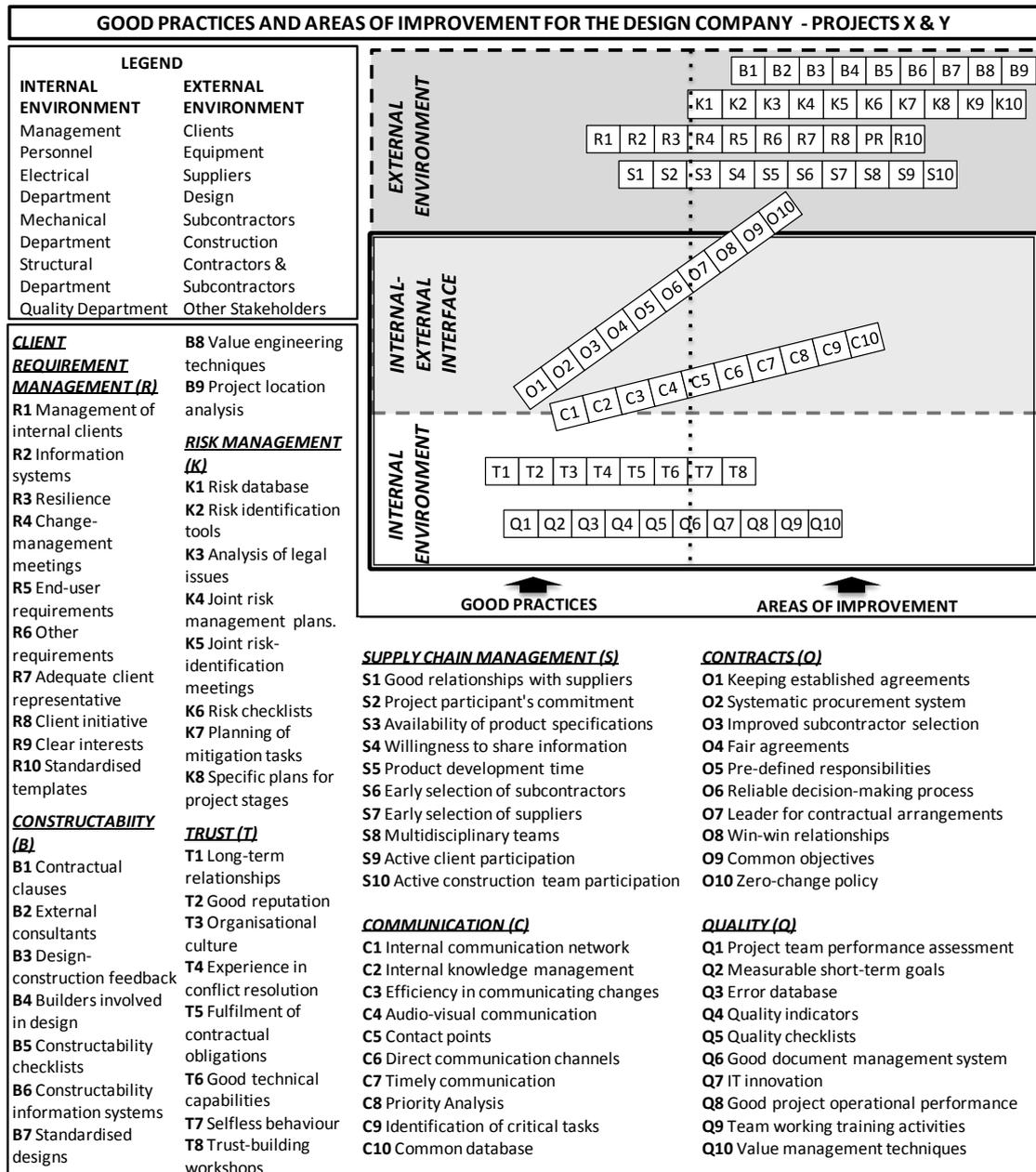


Figure 1: Good practices and areas of improvement for the design company

Trust (T) and Contracts (O)

The Company has shown good practices in terms of establishing contractual arrangements with clients and procuring design-related services from suppliers/subcontractors. In dealing with clients, the design firm has implemented a change-order management process through periodical meetings where cost and quality issues are discussed. Regarding the procurement of external services, the organisation has a supplier/subcontractor database and implements integral selection processes.

Indeed, good practices regarding trust and contracts within the Company have been found. However, none of the interviewees suggested that these concepts could be further improved. For example, projects are full of change orders because participants

have not previously established a zero change policy. This might start to be changed by implementing trust-building workshops in order to promote win-win relationships and common objectives among the project team (i.e.: clients, designers, contractors).

Quality (Q) and Communication (O)

The Company employs an internal information system that allows it to coordinate and make changes among different specialties. Moreover, the firm carries out a weekly-meeting program for every project, establishes measurable short-term goals in conjunction with quality checklists, and keeps records of all its meetings. Although this may seem as a structured DM approach, some interviewees (i.e.: designers) complained about the excessive workload needed to complete the projects under analysis. According to them, the firm needs to organise its communication channels with clients, suppliers, and contractors. In other words, the Company really needs to improve its interaction with the external environment. Based on that, it would be good for the organisation to undertake communication practices directed towards implementing prioritization analyses, identifying highly uncertain tasks, and developing value management and teamworking workshops.

RECOMMENDATIONS

It has been evident that the firm has a better performance in those areas concerning internal procedures than in those involving some degree of interaction with the external environment. Figure 1 shows that practices concerning trust and quality are among the best in the firm. This is because such concepts highly depend on the employees' abilities to provide a good service/product. In this sense, it is argued that thanks to the technical skills of its designers and managers, the Company has achieved a reputation that allows it to establish long-term relationships and increase work-in-hand. However, the Company needs to improve its external interaction methods in order to increase its design performance. This might be achieved by implementing the DM framework provided in Figure 2.

These ideas were discussed with some of the Company's directives in a final research workshop. They agreed with the resulting analysis and expressed their interest for implementing virtual design and construction (VDC) methods into their design processes. However, before implementing those techniques, the conceptual framework presented in Figure 2, was proposed as a proper path to improve the management of the design process within the organisation.

The framework consists of three main components. The first of them, on the left-hand side, represents the eight major design concepts studied. All the areas of improvement previously identified are depicted, as alphanumeric characters, in every row according to the concept they are part of (see Figure 1). The second element is composed of four columns and describes the maturity path to be followed by the Company (i.e.: Maturity path for improving the management of the design process). It is argued that before applying VDC methodologies, the firm should reach an advanced maturity level by learning how to work in teams, enhancing its design planning techniques, and managing clients' requirements efficiently. Finally, on the right-hand side, a series of implementation steps is briefly suggested (i.e.: implementation steps).

Based on Figure 2, multidisciplinary approaches play a key role in enhancing the whole DM process. Teamworking is particularly important for concepts such as risk management, supply chain management, constructability and communication. Since these ideas involve a high degree of interaction between the Company and the external

environment, it is advisable to implement collaborative approaches in the early project lifecycle phases. Integrative methodologies are not new to the construction industry. For example, value management workshops and constructability reviews have been applied both in the US and in the UK for many years. Therefore, the Company should explore the application of teamworking tools in order to be more competitive in its market segment through achieving innovative engineering solutions

| MATURITY PAH FOR IMPROVING THE MANAGEMENT OF THE DESIGN PROCESS | | | | | IMPLEMENTATION STEPS | |
|---|---|--------------------------|------------------------------|--------------------------------|----------------------|---|
| MULTIDISCIPLINARY TEAM WORK | | PLANNING & COMMUNICATION | SYSTEMATIC CLIENT REQ. MGMT. | COORDINATION BY VIRTUAL DESIGN | | |
| DM CONCEPTS AND PRACTICES | R | R4 R5 R8 | R4 R5 R8 R9 | R4 R5 R6 R7 R10 | R4 R5 R6 R10 | Transtion team ↓ Evaluation of real projects ↓ Selection of pilot project ↓ Implementation ↓ Results evaluation ↓ Learning feedback |
| | K | K2 K3 K4 K5 K7 K8 | K1 K4 K6 K7 | K6 | | |
| | B | B1 B2 B3 B4 B8 | B5 B6 | B8 B9 | B3 B4 B7 B9 | |
| | T | T7 T8 | T7 T8 | T7 T8 | T7 T8 | |
| | S | S5 S6 S7 S8 S10 | S3 S4 S6 S7 | S3 S6 S7 S9 | S5 | |
| | C | C5 C6 C7 C8 C9 | C4 C5 C6 C7 C8 | C10 | C4 C9 C10 | |
| | O | O7 O8 O9 | O7 O9 | O10 | | |
| | Q | Q7 Q9 Q10 | Q6 | Q10 | Q6 Q7 Q8 | |
| # good practice per design management concept | | | | | | |

Figure 2. Conceptual framework for enhancing the design management process

Interdisciplinarity implies better planning and communication techniques that allow the company to be more flexible and adaptable against external demands. These new tools may require new quality and performance indicators so that tasks can be properly controlled. Such techniques may include a common risk database for all project participants, an integrated document management system, and a design planning process that involves suppliers, contractors, clients, and designers.

Finally, once the Company has gained experience in teamworking methods and collaborative design planning techniques, systematic client requirements management system can be applied. This requires a standardised protocol to both identify and translate project risks into potential design alternatives. Such protocol should be based on transparent contractual arrangements focused on delivering engineering solutions. This step necessarily guides the Company into the implementation of VDC tools.

CONCLUSIONS

Analysis leads to conclude that the Company’s major areas of improvement lie in its relationships with the external environment. To bolster those areas, a conceptual framework has been proposed. The framework intends to provide a general path to achieve an integrated and collaborative design process. Although it is clear that further research is required, so the conceptual model can be fully implemented, this study is presented to show that the intuitive and iterative nature of design can be properly managed under local conditions.

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