A PCM PERFORMANCE EVALUATION SYSTEM FOR DESIGN/BUILD PROJECTS

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ABSTRACT: Professional Construction Management (PCM) services have become more and more popular in Taiwan in the past decade. However, disputes between PCM consultant and the client on the performance of PCM services are also increasing. The evaluation of PCM performance is a tough task due to the lack of "physical product", such as the drawings finished by the architect. This paper is intended to propose a PCM performance evaluation system (PPES) based on Balanced Scorecard (BSC). A case study of PCM consultancy for a real world design/build project is conducted to demonstrate the applicability of the proposed BSC framework

Key words : Balanced score card, PCM, performance management, case study, design/build

1. INTRODUCTION

Professional Construction Management (PCM) service was introduced into Taiwan one and half decades ago. It has become more and more popular in the last seven years as the publication of Government Procurement Law (GPL) [1], in which PCM was legalized. Moreover, as more and more complex construction projects (e.g., design/build and build /operate/transfer projects) were performed in public sector, the need of PCM services has also become desirous for the public owners.

Unlike the services of contractors and A/E consultants, PCM consultants usually do not provide physical products, such as constructed facilities or design drawings. Therefore, the scope of PCM service was disputed between the PCM consultant and the client. Evaluating the performance of PCM services has become a difficult task. It is desirable for both client and PCM consultant to develop a PCM performance evaluation system (PPES). This paper is intended to develop such a system for the D/B type projects in order to achieve two purposes: (1) providing objective criteria for both client and PCM consultant in order to manage the performance of PCM service; (2) equipping the PCM consultant with a self-improving tool to promote the quality of its service.

The proposed PPES adopts Balanced Scorecard (BSC) as basic framework for quantitative analysis and strategic planning. The key performance indicators (KPI's) related to the four perspectives of BSC (e.g., financial, customer, internal process, and learning & growth) were collected from GPL, literature reviews, former PCM service contracts, and questionnaire surveys. A PCM consultant was selected as the industrial partner for application verification of the established PPES. A real world D/B project performed by the industrial partner is used for demonstration of the proposed PPEF.

This paper is organized in the following manner: reviews of related literature are discussed in the next section; the KPI identification for the proposed PPES is detailed in Section 3; the BSC framework and the application procedure of the proposed PPEF is described in Section 4; application of PPEF to a real world D/B is demonstrated in Section 5; finally, conclusions and future works are summarized in Section 6.

2. LITERATURE REVIEWS

2.1 Performance Measurement

Performance measurement (PM) has been an active area since early of the 20th century. In the first quarter of the 20th century, some financial ratios indicating the performance of organization's financial performance were adopted as measures for PM [2][3]. These indicators have been adopted as the main performance evaluation tool for business organization ever since. Arguments on the adoption of financial ratios for performance evaluation started in 1950s [3][4]. Some new measurement systems were proposed after then, such as Keegan et al.'s performance matrix [5], Maskell's system based on world-class manufacturing measures [6], and Kaplan, R.S. and Norton's Balanced Scorecard (BSC) [7]. BSC was recognized as one of the most influential business tools in the past 75 years [4]. The BSC divides the performance measures of the organization into four perspectives: financial, customer, internal process, and learning & growth. There exist casual-effect

relationships between the indicators of the four perspectives. The relationships define the leading and lagging indicators in BSC. It is conceived that the value of leading indicator will affect the value of lagging indicator. The relationships of leading and lagging indicators form a strategic map that depict the strategies for increasing or decreasing the values of financial (lagging) indicators to achieve the business objectives of the organization.

2.2 Performance Measurement in Construction

Bassioni et al. proposed a conceptual framework for measurement of performance in construction [4]. They surveyed the PM of current construction practice in UK and found that three most popular PM systems are the Key Performance Indicators (KPI), the European Foundation of for Quality Management's (EFQM's) Excellence Models; and BSC. The KPI system was proposed by Egan to identify the best practice in construction industry [8]. The KPI indicators can be classified into two categories [9]: (1) project performance indicators—such as construction cost, construction time, predictability of cost, predictability of time, defects, and client's satisfaction in product and service; (2) company performance—such as safety, profitability, and productivity. The EFQM's Excellence Model is a self-assessment process to identify key areas for improvement. It was derived from the Total Quality Management (TQM) system [10].

Bassioni et al. also conducted an empirical evaluation of their proposed framework to domain experts in the UK construction industry. In their report, it was concluded that there exit gaps between knowledge and practice for performance evaluation. Further researches are needed to develop more comprehensive performance evaluation framework.

2.3 Performance Measurement in Project Management

This paper will focus on the evaluation of PCM's performance. However, it was found from literature review that very few research results were reported in this area. Dainty et al. conducted an empirical evaluation of performance measures for contractor's project management and concluded nine successful factors [12]: (1) team building; (2) leadership; (3) decision-making; (4) mutuality and approachability; (5) honesty and integrity; (6) communication; (7) learning, understanding, and application; (8)self-efficacy; and (9) external relations. Each factor represents a group of relevant indicators. Totally 43 indicators were identified. Dainty et al. also pointed out that the successful factors of contractor's project management consist of both hard quantitative performance criteria and soft human performance criteria. However, their focus was on the contractor's viewpoint rather than from the PCM consultant.

Perng proposed a client's satisfaction evaluation framework for PCM service [13]. His framework consists of 30 criteria that are categorized into the fives phases of a construction project lifecycle: preparation, procurement and contracting, design, construction, and turnover. The GPL of Taiwan also defines the content of PCM service, which consists of 23 items. These items are considered as pay-items in valuation of PCM service.

2.4 Summary of Literature Reviews

It is summarized from the reviews of literature that the performance of PCM service should be different from the PM of construction project or other A/E services, since the content of PCM service is relatively "soft" and more relevant to human aspect. However, tools of traditional PM systems can be used to construct the PPES, such as BSC. The indicators of such BSC can be identified from other PM systems in construction. The client's satisfaction and the requirements of government law are important considerations in developing PPES, too. All of these factors should take into account in order to establish a comprehensive performance evaluation framework for PCM service.

3. PCM SERVICES IN DESIGN/BUILD CONTRACTS

3.1 Importance of PCM Service in D/B Contracts

D/B contract is a relatively new project delivery approach in Taiwan. As it was regulated by the GPL in 1999, D/B has become a popular contract type in public works. The popularity of D/B contracts is due to couple of advantages: (1) single point responsibility—unlike traditional design/bid/build (D/B/B) system, D/B adopts a single contractor who is responsible for the whole project; (2) shorter schedule—the project duration can be significantly reduced due to the elimination of public bidding/procurement process and design changes; (3) cost effectiveness—D/B contract allows the contractor to propose alternatives for cost effectiveness according to its specialty and expertise. However, the D/B contract also induces new problems that are not severe in the traditional D/B/B system: (1) work scope management—definition of work become more complicated than ever; (2) difficulty on quality control—without the monitoring of A/E in traditional D/B/B system, quality insurance and quality control during construction process become more difficult; (3) selection of appropriate contractor—unlike the public bidding in traditional D/B/B system, D/B contract usually adopts most advantageous bidding due to non-homogeneousness of service. As a result, the public owners of D/B projects are in need of PCM service for managing the complicated project execution process of D/B contracts.

3.2 Scope of PCM Service in D/B Contracts

The PCM service in a D/B contract can be divided into three main stages: (1) Stage I—including project preparation, packaging, and bid awarding; (2) Stage II—D/B design; and (3) Stage III—construction management and delivery. In the first stage, the PCM helps the owner to analyze the characteristics of the project, define work scope for the project, prepare most advantageous bid package, and call for bidding. In the second stage, PCM helps the owner to monitor the quality and progress of the design process of the D/B contractor to insure that the design outcome complying

with the defined work scope. Finally, in the third stage, the PCM usually play similar role of A/E in traditional D/B/B system to control the construction quality and schedule. The content of PCM service in the three stages contains not only professional engineering services but also more about soft human aspects, such communication, coordination, and even politician [12]. All of these works are related to the performance of PCM service.

4. DEVELOPMENT OF PCM PERFORMANCE EVALUATION FRAMEWORK (PPEF)

This section describes the construction of the proposed PCM performance evaluation framework (PPEF). The PPEF will serve as the basis for the proposed PPES. As explained earlier in this paper, the methodology adopted here including literature reviews, questionnaire surveying, and interviews with domain experts. The literature reviews include the literature in published journals, theses, government regulations, and former PCM contracts.

4.1 Perspectives for Model Construction

In collecting the KPI's of PPEF, several perspectives need to be taken into account in order to angle a complete view of PPEF.

(1) Perspective of Project Objectives
The first perspective for KPI selection is the project objectives, which are time, cost, and quality performance of the project. Some researchers have argued that evaluation of the performance of PCM according to time, cost, and quality may be too crude due to that the planned time, cost, and quality objectives were developed when the project information is limited [12]. It's unfair to require project managers to stick strictly to the preset objectives. However, the pre-defined time, cost, and quality plans provide an objective standard for successful performance of the project. It is appropriate to include these three indicators in PPEF.

(2) Perspective of Project Management Process
According the discussion above, PCM service can be divided into three stages. Indicators should be divided into three categories according to the different service content in each stage.

(3) Perspective of Client Satisfaction
The ultimate goal of PCM service is to satisfy the client. Therefore, the indicators that reflect the client satisfaction perspectives should be included.

4.2 Collection of Performance Indicators for PPEF

Based on the discussions above, the KPI's of the proposed PPEF are collected from various sources as described in the following:

(1) KPI's from Relevant Government Regulations
The GPL defines PCM service items explicitly in the articles of the law. The service items are first categorized into the three stages and then transformed into related indicators such as time, cost, quality, or safety. Totally, 23 items are identified from GPL. Among those, 17 items are transformed into related performance indicators.

(2) KPI's from Literature
Previous researchers have identified promising indicators for PCM performance evaluation including those in literature reviews. Other researches such as Dzeng et al. have identified 27 indicators for schedule and budget control of public projects [14]. The KPI system proposed by Egan [8] identified 38 performance indicators for construction industry. Chang and Fung established a performance evaluation system for construction phase [15]. In their system, 17 performance indicators were identified.

(3) KPI's from Former Contracts
The work scope is defined in the contract. Thus, former PCM service contracts provide useful sources for KPI identification. In this research, ten D/B contracts were collected from former PCM service projects performed by the industrial partner, China Engineering Consultant, Inc. (CECI). Most of the projects are D/B residential construction projects. Totally, 30 performance indicators were identified.

(4) KPI's from Client Satisfaction Perspective
Client satisfaction indicators were collected from ISO 9001 (Version 2000) and a framework for evaluating client's satisfaction of PCM project proposed by Perng [13]. In Perng's framework, the client's satisfaction indicators were divided into two categories: (1) satisfaction of service process—consisting of responsiveness, schedule control ability, financial control and administration, document review ability, experience of PCM, and team work; (2) satisfaction of service results—consisting of quality of service, timeliness of service, effectiveness of constructed facility. Totally, 33 performance indicators were identified.

4.3 Preliminary Model of PPEF

The performance indicators identified in previous section are used for development of the preliminary model of PPEF. After eliminating the duplicated indicators and classifying the indicators into three stages, the preliminary model is constructed as shown in Table A.1 at the end of this paper. The PPEF comprises of 17 indicators in Stage I, 15 indicators in Stage II, and 22 indicators in Stage III. Some indicators are duplicated in two or three stages.

5. PCM PERFORMANCE EVALUATION

The proposed PPEF provides a framework for quantitative performance evaluation of PCM services. The indicators shown in Table A.1 form the foundation of the performance evaluation systems for each stage of PCM service. This section describes how the performance evaluation systems are developed, and how can they be applied.

5.1 Performance Evaluation System for PCM Services

Based on the performance indicators in the proposed PPEF and the BSC method, the performance evaluation system (PPES) for PCM service is developed. The proposed

PPES consists of a four-perspective quantitative evaluation framework and an associated strategic map. Figure 1 shows the indicators of the four perspectives in the BSC of the PPES. The associated strategic map of the BSC is shown in Figure 1.

Table 1. BSC of PPES

Perspect.	Strategic objective	Indicators in Each Stage		
		I	II	II
Financial	F_1 (Profitability)	IC_3, IC_4	MC_2, MC_3	FC_3, FC_4
	F_2 (Cost effectiveness)	IC_1, IC_2	MC_1	FC_2
Customer	C_1 (Service)	IS_3, IS_4	MS_3	FS_2, FQ_8
	C_2 (Satisfaction)	IQ_4, IQ_8	MQ_4, MQ_8	FQ_3, FQ_{12}
Internal Process	I_1 (PM)	IQ_5	MQ_5	FC_1, FQ_5, FQ_{10}
	I_2 (Process)	IQ_3	MQ_3	FQ_2, FQ_6, FQ_7
	I_3 (Expertise)	IS_2, IC_5, IQ_2	MS_2, MC_4, MQ_2	FS_1, FC_5, FC_6, FQ_1
	I_4 (Quality)	IQ_6	MQ_6	FQ_4, FE_1, FE_2,
Learning & growth	L_1 (Human resource)	IQ_7	MQ_7	FQ_9
	L_2 (Expertise)	IS_1, IQ_1	MS_1, MQ_1	FQ_{11}

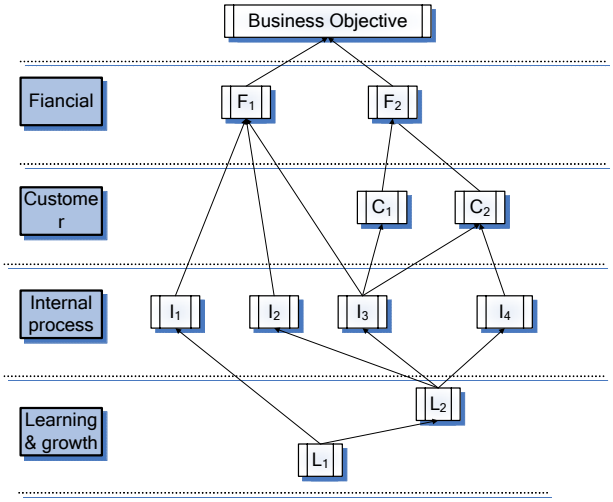

Figure 1. Strategic Map of PPES

5.2 Process of Performance Evaluation

The procedure of performance with the proposed PPES consists of five steps:

(1) Determining weightings of KPI's—the relative weightings of the indicators in each level of PPES should be determined first. The Analytic Hierarchical Process (AHP) [16] can be adopted for this purpose.

(2) Assessment of KPI values for indicators at the bottom level of PPES—the values of quantitative indicators have been defined by quantitative equations; while the values of qualitative indicators are determined through a sub-quantitative method that bases on the subjective judgment of the user.

(3) Aggregating the weighted values of indicators in lower level with the weightings determined in step (1).

(4) Plotting time-series diagram for the values of strategic objectives of the four perspectives.

(5) Identifying potential performance problems and proposing improvement strategies.

5.3 Case Study

A D/B residential project of a national university located in Taipei is selected for demonstration of the proposed PPES. The project consists of design and construction of 10 residential buildings located in 10 different sites. Total budget of project was USD 11.8 million. The construction period was from Sept. 2002 to July 2004. The proposed PPES was applied to evaluate the PCM performance of Stage I to Stage III. The time-series monitoring of the PCM performance of the case project is shown in Figure 2.

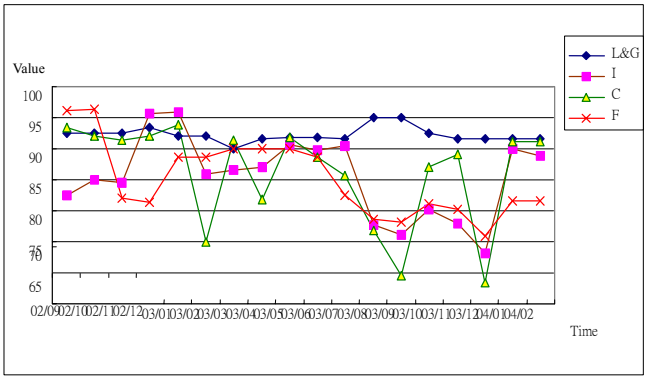

Figure 2. Time-Diagram for Performance Monitoring

The case study was a post-evaluation demonstration. Historical data collected from project report documents were used for testing of PPES. Figure 2 depicts the truth that values of leading indicators imply the trends of the values of lagging indicators. Only the learning and growth indicator was stable throughout the project lifecycle. Other three indicators were dramatically fluctuating. The fluctuation started from the poor performance of internal process indicator in Stage I, and then caused declining of the financial indicator in Stage II. Even though the PCM consultant soon found the problem and improved the internal process indicator, the customer has dissatisfied with the poor internal process at the beginning of the project. It was found at the end of the project, the internal process, customer, and financial indicators correlated one another. The result was a poorly performed PCM service.

Improvement strategic can be proposed based on the strategic map. From Figure 2, there was a chance in Stage II to make up the poor performance in Stage I. However, the PCM consultant did not recognize the trend of key strategic objectives and missed the best timing for performance improvement.

6. CONCLUSION AND FUTURE WORK

The research proposes a PCM performance evaluation system (PPES) based on the Balanced Scorecard method.

The KPI's of the proposed system were collected from a variety of sources, and categorized into three stages: 17 indicators in Stage I, 15 indicators in Stage II, and 22 indicators in Stage III. The proposed PPES can be used for two purposes: (1) as a standard of PCM performance evaluation for the client; (2) as a tool of self-improving for the PCM consultant.

A real world D/B construction project was selected for demonstration of the proposed PPES. It was found that the proposed PPES is useful for monitoring the performance of PCM services. Moreover, PPES is capable of identifying potential problems from time-series diagram. Improvement strategies can be proposed based on the strategic map.

This research has established the preliminary framework for PCM performance evaluation. Such framework should be refined and tailored to fit the performance evaluation of different project types. Moreover, the patterns shown in time-series diagram deserve further research, too.

ACKNOWLEDGEMENT

This research received tremendous aids from the industrial partner, China Engineering Consultants, Inc. (CECI). The authors would like to express sincere appreciations to CECI.

REFERENCES

[1] Public Construction Commission, *Government Procurement Law*, Public Construction Commission of Executive Yuan, Taiwan, 2003.

[2] Chandler, A. D., *The visible hand: The managerial revolution in American business*, Harvard University Press, Cambridge, MA, USA, 1977.

[3] Kaplan, R. S., *The revolution of management accounting, Accounting Review*, Vol. 59, No. 3, pp. 390-418.

[4] Bassion, H. A., Price, A. D. F., and Hassan, T. M., "Performance Measurement in Construction," *Journal of Management in Engineering*, ASCE, Vol. 20, No. 2, pp. 42-50, 2005.

[5] Keegan, D. P., Eiler, R. G., and Jones, C. R., "Are your performance measure obsolete?" *Manage. Account.*, Montvale, Vol. 70, No. 2, pp. 45–50, 1989.

[6] Maskell, B. "Performance measurement of world class manufacturing," *Manage. Account.*, Vol. 67, No. 5, pp. 32–33, 1989.

[7] Kaplan, R.S. and Norton, D.P. "The balanced scorecard – measures that drive performance," *Harvard Business Review*, January–February, pp. 71–79, 1992.

[8] Egan, J. "Rethinking construction," *Report to Dept. of the Environment, Transport and the Regions*, London, UK, 1998.

[9] Beatham, S., Anumba, C.J., Thorpe, T. and Hedges, I. "KPIs – a critical appraisal of their use in construction," *Benchmarking: An International Journal*, Vol. 11, No. 1, pp. 93–117, 2004.

[10] British Quality Foundation, *The Model in Practice – Using the EFQM Excellence Model to Deliver Continuous Improvement*, The British Quality Foundation, London, UK, 2002.

[11] Bassion, H. A., Price, A. D. F., and Hassan, T. M., "Building a conceptual framework for measuring business performance in construction: an empirical evaluation," *Construction Management and Economics*, Vol. 23. No. 5, pp. 495-507, 2005.

[12] Dainty, A. R. J., Cheng, M. I., and Moore, D. R., "Redefining performance measures for construction for construction project managers: an empirical evaluation," *Construction Management and Economics*, Vol. 21. No. 2, pp.209-218, 2003.

[13] Perng, S. C., "Satisfaction evaluation of PCM service for construction project management," *Master Thesis*, Institute of Construction Management, Chung Hua University, Hsinchu, Taiwan, 2003. (in Chinese)

[14] Dzeng, R. J., Huang, Y. L., and Lue, S. S., "Review of Current Public construction Schedule and Budget Control Systems," *Report to Public Construction Commission*, Public Construction Commission, Executive Yuan, Taipei, Taiwan, 1998. (in Chinese)

[15] Chang, S. T., and Fung, Y. K., "Establishment of Public Construction Performance Evaluation System," *Report to Public Construction Commission*, Public Construction Commission, Executive Yuan, Taipei, Taiwan, 2002. (in Chinese)

[16] Saaty, T. L., *The analytic hierarchy process: Planning, priority setting, resource allocation*, McGraw-Hill, London, UK, 1980.

Table A.1. Indicators of the Proposed PPEF

Stage	Symbol	Indicator	Description	Criterion for normality	Quantitative/ Qualitative
I	IS_1	Schedule planning	Planned schedule/contracted schedule	≦1	Quantitative/
	IS_2	Schedule control	Actual progress/planned progress	≧1	Quantitative/
	IS_3	Timeliness	Completion duration/Contracted duration	≦1	Quantitative/
	IS_4	Awarding failure	Accumulative times of awarding failure	≦0	Quantitative/
	IC_1	Budgeting	Planned budget/Budget of Owner	≦1	Quantitative/
	IC_2	Award variance	Awarded price/Approved budget	≦1	Quantitative/
	IC_3	Profitability	Accumulated cost/ accumulated income	≦1	Quantitative/
	IC_4	Forfeiture ratio	Accumulated fined/ accumulated income	≦0	Quantitative/
	IC_5	Cost control	BCWP/ACWP	≧1	Quantitative/
	IQ_1	Financial analysis	Ability on key financial issues	good	Qualitative
	IQ_2	Review time	Σ(Actual vs. planned review time/No. of reviews)	≦1	Quantitative/
	IQ_3	Document management	Systemization of document management	computerized	Qualitative
	IQ_4	Coordination	Mechanisms for communication and coordination	documented	Qualitative
	IQ_5	PM	(Schedule control＋Cost control)/2	≧1	Quantitative/
	IQ_6	QA	No. of quality defectives	0	Quantitative/
	IQ_7	Personnel's experience	Σ(Years of personnel's experience)/No. of personnel	≧10	Quantitative/
	IQ_8	Client's satisfaction	No. of client appreciations-No. of client complaints	≧1	Quantitative/
II	MS_1	Schedule planning	Planned schedule/contracted schedule	≦1	Quantitative/
	MS_2	Schedule control	Actual progress/planned progress	≧1	Quantitative/
	MS_3	Timeliness	Completion duration/Contracted duration	≦1	Quantitative/
	MC_1	Budget control	Estimated cost of design solution/contracted price	≦1	Quantitative/
	MC_2	Profitability	Accumulated cost/ accumulated income	≦1	Quantitative/
	MC_3	Forfeiture ratio	Accumulated fined/ accumulated income	0	Quantitative/
	MC_4	Cost control	BCWP/ACWP	≧1	Quantitative/
	MQ_1	Financial analysis	Ability on key financial issues	good	Qualitative
	MQ_2	Review time	Σ(Actual vs. planned review time/No. of reviews)	≦1	Quantitative/
	MQ_3	Document management	Systemization of document management	computerized	Qualitative
	MQ_4	Coordination	Mechanisms for communication and coordination	documented	Qualitative
	MQ_5	PM	(Schedule control＋Cost control)/2	≧1	Quantitative/
	MQ_6	QA	No. of quality defectives	0	Quantitative/
	MQ_7	Personnel's experience.	Σ(Years of personnel's experience)/No. of personnel	≧10	Quantitative/
	MQ_8	Client's satisfaction	No. of client appreciations-No. of client complaints	≧1	Quantitative/
III	FS_1	Schedule control	Actual progress/planned progress	≧1	Quantitative/
	FS_2	Timeliness	Completion duration/Contracted duration	≦1	Quantitative/
	FC_1	Change ratio	Σ(｜actual change cost｜＋｜estimated change cost｜)/contracted cost	≦2%	Quantitative/
	FC_2	Completion cost ratio	Σ｜actual completion cost｜/contracted budget	≦2%	Quantitative/
	FC_3	Profitability	Accumulated cost/ accumulated income	≦1	Quantitative/
	FC_4	Forfeiture ratio	Accumulated fined/ accumulated income	0	Quantitative/
	FC_5	Cost control	BCWP/ACWP	≧1	Quantitative/
	FC_6	No. of budget changes	Accumulated No. of budget changes	0	Quantitative/
	FQ_1	Review time	Σ(Actual vs. planned review time/No. of reviews)	≦1	Quantitative/
	FQ_2	Document management	Systemization of document management	computerized	Qualitative
	FQ_3	Coordination	Mechanisms for communication and coordination	documented	Qualitative
	FQ_4	QA	No. of quality defectives	0	Quantitative/
	FQ_5	PM	(Schedule control＋Cost control)/2	≧1	Quantitative/
	FQ_6	Inspection (material)	No. of successful first inspections for material/Total No. of PCM inspections	≦1	Quantitative/
	FQ_7	Inspection (install)	No. of successful first inspections for installation/Total No. of PCM inspections	≦1	Quantitative/
	FQ_8	Equipment Testing	No. of unsuccessful first inspections for installation/Total No. of PCM inspections	≦1	Quantitative/
	FQ_9	Personnel's experience	Σ(Years of personnel's experience)/No. of personnel	≧10	Quantitative/
	FQ_{10}	Contract risk management	No. of dispute and arbitration claims	0	Quantitative/
	FQ_{11}	Education	Σ(Planned training persons)/(actually trained persons)	≧1	Quantitative/
	FQ_{12}	Client's satisfaction	No. of client appreciations-No. of client complaints	≧1	Quantitative/
	FE_1	Safety	No. of safety accidents	0	Quantitative/
	FE_2	Environmental	No. of environment protection awards－No. of fines	≧1	Quantitative/