

FLEXIBLE MULTI-CRITERIA INTEGRATED PERFORMANCE-BASED  
DECISION MODEL FOR CONTRACTOR SELECTION

NURSHIKIN BINTI MOHAMAD SHUKERY

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*To Almighty ALLAH, Alhamdulillah.*

*Mak, for her endless prayers.*

*Ayah, Al-Fatihah.*

*Husband and kids, for their love, patience and supports.*

*Relatives and Friends.*

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## ABSTRACT

Contractors are one of the important team members in a construction project, they translate design and specifications into reality. Involvement of contractors in a project begins after they successfully make it through the preliminary screening process and win the bid for the project tender. Statistics released by construction industry agencies showed that the overall level of contractor performance are low. Researchers and professionals within the construction industry often relate the contractor performance with weaknesses within the current contractor selection system. The current contractor selection system is usually based on the lowest bid price, subjective assessment, neglecting performance criteria and does not act as a flexible decision making tool. Hence, this study aims to develop an integrated multi criteria decision making model based on performance for contractor selection. Mixed mode research methodology was used in identifying performance criteria and ensuring accuracy of the model developed. Interviews with six experts were conducted to identify weaknesses of the current system, the assessment method for performance criteria and integration of the model into the current assessment system. Whereas online questionnaires responded by 40 experienced quantity surveyors were used to determine the weighting factor for the determined performance criteria. Content analysis was used to interpret interview data and descriptive statistics method was used to determine relative importance of performance criteria. This research identified 22 contractor performance criteria divided into two groups; those of past performance (11 criteria) and potential performance (11 criteria). Quality of work in past projects and rate of failure to complete past contracts satisfactorily or failure to complete projects within the pre-determined time frame are the main past performance criteria. Whereas the main potential performance criteria are depth of experience in similar projects and labour resources. The Analytical Hierarchy Process (AHP) method is used to develop a multi criteria contractor selection system to assist in decision making when faced with multiple subjective criteria which are often contradictory. A web based prototype of the flexible multi criteria contractor selection model based on performance has been developed in conjunction with the objective of this research. The developed prototype is integrated into the current contractor selection system to be tested and validated by quantity surveyors in the public sector. Test results showed significantly similar opinions among all experts, towards the use of the proposed flexible multi criteria contractor selection model based on performance. The resulting model in this research succeeded in choosing the most capable contractor and produced consistent results. Feedback from contractors also validated that the resulting model is practical enough to be applied in the construction industry.

## ABSTRAK

Kontraktor merupakan salah satu ahli pasukan yang penting dalam sesebuah projek pembinaan, mereka menterjemahkan rekabentuk dan spesifikasi kepada realiti. Penglibatan kontraktor dalam sesebuah projek bermula selepas mereka berjaya melepasi proses saringan dan memenangi bidaan ke atas tender projek. Perangkaan yang dikeluarkan agensi industri pembinaan menunjukkan tahap prestasi keseluruhan kontraktor adalah rendah. Penyelidik dan professional dalam industri pembinaan sering mengaitkan prestasi kontraktor dengan kelemahan pada sistem pemilihan kontraktor sedia ada. Sistem pemilihan kontraktor sedia ada lazimnya berdasarkan tawaran harga paling rendah, penilaian yang subjektif, mengabaikan kriteria prestasi dan tidak bertindak sebagai alat pembuat keputusan yang fleksibel. Oleh itu, kajian ini bertujuan untuk membangunkan sebuah model keputusan berbilang kriteria bersepadu yang berasaskan prestasi untuk pemilihan kontraktor. Kaedah mod campuran digunakan dalam mengenalpasti kriteria prestasi dan memastikan ketepatan model yang dibangunkan. Temubual dengan enam orang pakar dijalankan bagi mengenalpasti kelemahan sistem yang sedia ada, kaedah penilaian kriteria prestasi dan menyepadukan model ini dalam sistem penilaian yang sedia ada. Manakala soalselidik atas talian yang dijawab oleh 40 jurukur bahan berpengalaman digunakan untuk menentukan faktor pemberat kriteria prestasi yang telah ditentukan. Analisis kandungan digunakan untuk mentafsirkan data temubual dan kaedah statistik deskriptif digunakan untuk menentukan kepentingan relatif dikalangan kriteria prestasi. Penyelidikan ini telah mengenalpasti sebanyak 22 kriteria prestasi kontraktor dan terbahagi kepada dua kumpulan iaitu prestasi lepas (11 kriteria) dan prestasi potensi (11 kriteria). Kualiti kerja dalam projek lalu dan kadar kegagalan menyempurnakan kontrak lepas dengan betul atau gagal menyempurnakan projek mengikut tempoh yang ditetapkan adalah kriteria prestasi lepas yang utama. Manakala kriteria prestasi potensi yang utama pula adalah kedalaman pengalaman terhadap projek yang sama dan sumber tenaga kerja. *Analytical Hierarchy Process* (AHP) digunakan untuk membangunkan sistem pemilihan kontraktor berbilang kriteria bagi membantu pembuat keputusan dengan berbagai kriteria yang subjektif dan bercanggah diantara satu sama lain. Prototaip berasaskan web bagi model pemilihan kontraktor berbilang kriteria yang fleksibel berasaskan prestasi telah dibangunkan selaras dengan objektif penyelidikan ini. Prototaip yang telah dibangunkan disepadukan dengan sistem pemilihan kontraktor sedia ada untuk diuji dan disahkan oleh Juruukur Bahan dalam sektor awam. Hasil ujian tersebut menunjukkan bahawa terdapat kesamaan signifikan antara kesemua pakar terhadap cadangan model pemilihan kontraktor berbagai kriteria yang fleksibel berasaskan prestasi. Model yang dihasilkan dalam penyelidikan ini berjaya dengan memilih kontraktor yang berkeupayaan dan menghasilkan keputusan yang konsisten. Maklum balas daripada kontraktor juga mengesahkan model yang dihasilkan praktikal untuk dilaksanakan dalam industri pembinaan.

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## LIST OF ABBREVIATIONS

A/E	-	Architectural/Engineering
AHP	-	Analytic Hierarchy Process
ANP	-	Analytical Network Process
APM	-	Association of Project Management
BQ	-	Bill of Quantities
CIDB	-	Construction Industry Development Board
CPC	-	Certificate of Practical Completion
CR	-	Consistency Ratio
D & B	-	Design & Build
DoD	-	Department of Defence
DSS	-	Decision Support System
ELECTRE	-	Elimination and Choice Expressing Reality
EMR	-	Experience Modification Factor
EPF	-	Employees Provident Fund
FRBK	-	<i>Faktor Pelarasan Baki Kerja</i>
GUI	-	Graphic User Interface
LAD	-	Liquidated and Ascertained Damages
LSABQ	-	Lump Sum-Approximate Bill of Quantities
LSDS	-	Lump Sum-Drawing and Specification
LSFBQ	-	Lump Sum-Firm Bill of Quantities
MAUT	-	Multi Attribute Utility Theory
MCDA	-	Multi-Criteria Decision Analysis
MOF	-	Ministry of Finance
MP10	-	10 <sup>th</sup> Malaysian Plan
MP9	-	9 <sup>th</sup> Malaysian Plan
OSHA	-	Occupational Safety and Housing Administration
PC	-	Personal Computer

PKK	-	Pusat Khidmat Kontraktor
PWD	-	Public Works Department
QS	-	Quantity Surveyor
RNC	-	Reasons for Non-Compliance
SAKPKR	-	<i>Surat Arahan Ketua Pengarah Kerja Raya</i>
SCORE	-	Program Penilaian Keupayaan dan Kemampuan Kontraktor
SKALA	-	Project Management System
TCL	-	Treasury Circular Letter
TI	-	Treasury Instruction
TOPSIS	-	Technique for Order Preference by Similarity to Ideal Solution

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Background to the research**

The difficulty of the construction industry involves complex business process and generates series of contractual liabilities (Standard Tender Documents, 2010). Every construction project is unique and each project has their own characteristic in terms of design, site conditions, construction materials, labours requirements, plants and equipment requirements, construction methods, technical complexity and level of management skill required. Other uniqueness of construction project are the involvement of several different stakeholders and responsibilities; such as client, contractors, architects, engineers, approving authorities, supplier and labours (Haseeb, *et al.*, 2011). The management of a construction project itself involves four different phases, which represent a chain of huge amount of activities. The four phases of construction projects are identified as project initiation, project planning, project execution and project closure, and each phase have different characteristics and different management requirements (Maylor, 2003). The success of a project depends on meeting project objectives within time, budget limits and quality according to stakeholder's satisfaction (Abedi, 2011). Research by Faridi & El-Sayegh, (2006) on factors causing delay in construction project in United Arab Emirates (UAE) indicate that 50% of construction project experience delays affect the interest of all stakeholders, and Orozco, *et al.*, (2011) confirmed that delays are a common problem that affect the competitiveness of construction companies.

Public Works Department has developed a database system to monitor project performance called Project Management System (SKALA). According to

SKALA (2014), 53.5% of projects were delayed out of 299 projects awarded between the 9<sup>th</sup> Malaysian Plan 9 (MP9) and the 10th Malaysian Plan (MP10). According to Sambasivan & Soon, (2007), five of the cause for delay were dominated by contractors; namely improper contractor's planning, poor contractor's site management, inadequate contractor experience, shortage in material and labour supply, equipment availability and failure, and mistakes during construction stage. Another recent study by Ali, *et al.*, (2010) added that contractors' financial difficulties and defective works contributed to project delays in Malaysia. It is an indicator that contractors are the main players in Malaysian construction industry, where the incompetence of contractors may lead to project delays. It is time for the Malaysian construction industry to rethink its current contractor selection practice and develop a comprehensive contractor selection approach in order to minimise project delivery problems related to contractors.

## **1.2 Research problems and gaps**

Selection of a contractor is a vital process that helps in selecting experienced and financeable contractors for the success and quality of works (Yilmaz & Ergönül, 2011). Although many clients are aware that the lowest bid does not always result in lower costs and better quality, bid price has always been regarded as the most crucial factor for the selection process (Xu, *et al.*, 2014). El-Abbasy, *et al.*, (2013) conducted a structural questionnaire survey within United States, Canada and the Middle East on appropriate contractor selection and concluded that selecting contractors using the lowest price bid may not result in an optimum solution to the construction problem. The lowest price bid may lead to poor construction, low quality, unavoidable claims and disputes, increase in sub-standard quality, cost overruns and delays (Palaneeswaran & Kumaraswamy, 2001a; Palaneeswaran, Ng, & Kumaraswamy, 2006; Tao & Kumaraswamy, 2012). In conjunction to overcome such limitation, a multi-criteria contractor selection has been developed by previous researchers based on financial soundness, technical ability, management capability, and safety and health performance (Hatush & Skitmore, 1997); past performance (Watt, *et al.*, 2010); plant and equipment (Plebankiewicz, 2010); and track

performance (Idrus, *et al.*, 2011). After the evaluation process, a contractor with the highest marks is recommended by the committee for the project award.

In Malaysia, projects under the Malaysian Ministry of Works have the highest number of project delays reported. According to statistics, 23 project delays and 16 failed projects out of 84 projects awarded; followed by the Ministry of Health, with 20 projects delays and 7 projects failed out of 42 projects awarded (SKALA, 2014). Reasons project delays are occurring in Malaysia are due to labour shortage, lack of skill, poor planning and scheduling by the contractor (Abdul-Rahman, *et al.*, 2006), contractors' financial difficulties, construction mistakes and defective works (Ali, *et al.*, 2010) during the construction phase. All of these reasons are contractor-related factors. Time and cost overruns, disputes, arbitration, and even total abandonment are implications of incompetent contractors (Ofori, 1993; Kaming, *et al.*, 1997; Memon, *et al.*, 2011).

Ramanathan, *et al.*, (2012) indicated that government public works projects are the biggest consumer of the Malaysian construction industry. The Public Works Department (PWD), under the Ministry of Works, provides technical advisory and is responsible for developing infrastructures and the construction industry in the public sector. PWD's tender evaluation and contractor selection system is divided into two main criteria; namely financial capabilities and technical capabilities. PWD has developed a fine and objective evaluation for the financial criteria. Evaluation of the contractor's financial capability has not been a major issue in subjective judgment or bias. A study conducted by Jaafar, *et al.*, (2006) indicates that during contractor selection, client emphasised more on contractor's capabilities in financial matter but technical capabilities have not been given priority. These findings could be the reasons for the lower ranks in previous performance record and in contractor work experience. Evaluation of contractor's technical capability is influenced by subjective judgment by evaluators and lack of past performance evaluation. PWD contractor selection system is lacking in tools and systems to evaluate contractors based on past performance and potential performance (Ariffin, 2014). Poor contractor selection criteria may result in poor current and future project performance in Malaysia construction industry.



Various methods and interventions in improving the quality of contractor selection criteria and processes have been developed. Research by Hosny, *et al.*, (2013); Nassar & Hosny, (2013); Tao & Kumaraswamy, (2012); Singh & Tiong, 2006; and Wong, (2004), suggested that the most reliable indicator to envisage future performance of contractor is a contractor's past performance. Past performance of contractors enables prediction of multiple project performance outcomes for candidate contractors (Alarcon & Mourgues, 2002), by using performance modelling process. Research by El-Sawalhi, *et al.*, (2007), found contractors to be reliable when their past work performance was considered in the selection process and Padhi & Mohapatra, (2009) suggested that contractors' past performance be incorporated in their bids of multiple projects. It is important to emphasise on the evaluation of past contractor performance in order to determine previous experience and reputation of the contractor; and to highlight the evaluation of potential contractor performance in order to determine the capability of the contractor in carrying out the project.

This research takes it to the next level by integrating performance-based contractor selection system and improving only the technical ability criteria by incorporating past performance and potential performance indicators into the existing PWD's practice. According to White, (2000), changing the whole system would lead to confliction and cannot be planned well. Therefore, this Flexible Multi-criteria Integrated Performance-based Decision Model for Contractor Selection is not trying to revamp the whole system, but only enhancing one of the criteria that influence the weakness of the whole system. The Performance-based Contractor Selection System is looking on practicality, which is less radical than other contractor selection models. The reasonableness of the system will benefit practitioners in selecting the right contractor based on his performance.

### **1.3 Research questions**

Based on the background and research problem, the following research questions are posed:

1. What are the criteria and sub-criteria that should be used in a performance-based contractor selection system?
2. What are the weighting factors for each criteria and sub-criteria in the performance-based contractor selection system?
3. How are the performance-based assessment module integrated into the existing contractors' evaluation framework?
4. Is the Flexible multi-criteria integrated Performance-based decision model for contractor selection valid?

### **1.4 Objective of the research**

The aim of this research is to develop a Flexible multi-criteria integrated Performance-based decision model for contractor selection in order to answer the above-mentioned research questions. The following is set out as the specific objective for this study.

1. Determine the criteria to be used to evaluate contractor based on past and potential performance of a contractor.
2. Establish weighting factors of each past and potential performance criteria.
3. Establish objective assessment of contractors' past and potential performance criteria.
4. Integrate performance-based contractor selection module into existing contractors' evaluation framework.

5. Validate efficacy of proposed performance-based contractor selection model.

### **1.5 Scope of research**

In Malaysia's 2014 budgets, the government allocated RM46.5 billion on the overall nation's development, with RM3.58 billion allocated to the Ministry of Works for building and infrastructure development expenditure (Buletin Kerja Raya, 2013). PWD is an agency under the Ministry of Works. Even though the tendering guidelines for the public sector is managed under the Ministry of Finance (MOF), PWD is the main advisory to the MOF in developing the guidelines and the Standard Operation Procedure of the tendering system, and responsible for implementation of development projects and maintenance of infrastructure assets under the public sector. According to MOF, (2008), all tendering practice; tender evaluation and contractor selection must be performed by experts in those particular services. PWD is an important organisation for the case study and Quantity Surveyors (QS) were responsible for tendering evaluation and contractor selection process in the public sector. Feedbacks from other construction industry stakeholders such as contractors, consultants, engineers, architect, etc. may produce a diverse and variety of opinions on whether to second or to object the idea of developing a performance-based contractor selection. Hence, it will take a longer period to analyse each category of respondents. In order to develop a performance-based contractor selection system, this research only focuses on opinions and feedbacks from the QS, who is well informed with the current contractor selection system. After the Performance-based Contractor selection has been developed, this research will seek opinions from G7 contractors on the potential of this module to be implemented in PWD contractor selection practice.

## **1.6 Significance of the study**

The Flexible Multi-criteria Integrated Performance-based Decision Model for Contractor Selection is established to improve existing PWD contractor selection practice by integrating past performance and potential performance into the system. This research is expected to contribute to the body of knowledge and industry by proposing an evaluation system which emphasizes on performance criteria that can be used by the public and private projects alike.

This research provides significant benefits to knowledge contributions in terms of decision making model. This research is expected to provide decision model that transform subjective judgement into objective measure in contractor selection. The criteria and weightage developed is based on the combinations of extensive literature reviews and responses from the respondents. The developed criteria and weightage of this model is flexible and can be modified to suit the objective of the projects, sectors or different country requirements. The flexibility, applicability and the reliability of this Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection is validated by the experts in PWD. The model can be used by others in different projects, sectors or regions.

As contribution to the practice, the Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection evaluation will allow the selection of a competent contractor since past performance criteria is a reliable indicator to determine future contractor performance. From the contractors' perspective, this will serve as a benchmark for contractors to enhance their performance in order to strive for their next future job, and also provides the contractor with more reliable and transparent tender evaluation.

As for benefits for the construction industry, this research helps in developing an understanding on the concept of Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection and how it can motivate project stakeholders to improve project performance and quality in order to decrease the

number of project delivery problems, and indirectly enhance project performance in the Malaysian construction industry.

## **1.7 Research Methodology**

Based on the research problem, the pragmatic approach appears best suited for the case study of this research. According to Feilzer, (2010), pragmatism is a research paradigm which supports the use of a mix of different research methods as well as modes of analysis and a continuous cycle of deductive reasoning while being guided primarily by the researcher's desire to produce socially useful knowledge. Pragmatism concentrates on beliefs that are more directly connected to actions (Morgan, 2014), where this research believes that Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection can be implemented in the public sector to address limitations of existing practices. Qualitative and quantitative methods are used simultaneously.

This research starts with a pilot survey to a small group of QS, then the findings are used to construct interviews questions to a focus group of well-experienced and knowledgeable QS, and finally questionnaire questions are developed for a larger group of QS in PWD. This research managed to conduct 6 interviews by using purposive sampling and snowballing techniques. According to Hair Jr, *et al.*, (2011) purposive sampling technique involves selecting elements in the sample for a specific purpose as they represent the target population who are willing to provide such information by their extent of knowledge and experience. Questionnaire surveys were emailed and delivered to 217 Quantity Surveyor who were currently working with PWD in Malaysia. Online questionnaires were distributed to respondents via email. According to Wright, (2005), online survey research using software packages and services are easier for both respondents and researcher, and produce faster results. For this research, an online survey using Google Form was used to facilitate the ease of survey distribution for faster results.

Qualitative data derived from interviews and documentations regarding an overview of the construction industry, contractor performance, current tender

evaluation practices, performance indicators, and assessment methods were analyzed using MaxQDA software. This software helps the researcher to organise, code, determine themes to develop and map the thematic diagram of performance-based criteria from the interviews' data. Quantitative data from questionnaire surveys regarding the level of importance of performance criteria were stored and analysed using Microsoft Excel. Descriptive statistics methods were used to summarize and describe the data.

Weighting factor for each performance indicators' criteria was determined using Analytical Hierarchy Process (AHP). Using AHP allows the user to analyse a decision problem in detail in terms of precision of estimation and assessment consistency (Jaskowski, *et al.*, 2010). Weighting factors were used to develop a prototype of Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection system using Server2Go application, a stand-alone webserver. The prototype enables users to run it on a USB drive or on a write protected media (such as a DVD). The Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection system and the prototypes are validated by experts to ensure validity of the system to reflect its potential objectivity, to determine correctness of the input and output, to be benefited by the construction industry.

## **1.8 Limitation of Study**

This pragmatic research requires a comprehensive data or a complete picture of what's being studied. This research focuses on the PWD contractor selection system; therefore a case study is adopted. Limitations of the case study research are the strategic selection of respondents. Representative or random samples may not be the most appropriate, given that they may not provide the richest insight of a case study. Other limitation of a case study is that the results are hard to generalise. Data gathered is limited, and overall questions the usefulness of the case study method and the practicality of how applications generated from the study can be useful to the public sector. However, some private sectors that applied the PWD contractor selection system may have the advantage in applying the Flexible Multi-Criteria

Integrated Performance-based Decision Model for Contractor Selection system in their organization.

A purposive sampling and snowballing are the only method that is best suited to the nature of this research; requiring well-experienced and knowledgeable respondents. Purposive and snowballing techniques are time-consuming because the interview is only conducted if the person suggested (by previous respondent) agrees to participate. Interviews will stop once the saturation of data has been achieved.

## **1.9 Definition of terms**

Major terms used in this research are defined here for the clarity of the objectives of this research.

### **i. Performance**

Performance is a process that quantifying action and actions that lead to performance (Neely, Gregory, & Platts, 2005). However, in construction industry context, in response to Egan's Report (1998) key performance indicators consist of seven project performance indicators, namely: construction cost, construction time, cost predictability, time predictability, defects, client satisfaction with the product and client satisfaction with the service; and three company performance indicators, namely: safety, profitability and productivity (Takim & Akintoye, 2002). However, the performance of the stakeholders by evaluating their expectations and contributions is the criteria for success (Atkinson, 1999). With respect to this research, performance is therefore focus on the performance of contractor.

### **ii. Past performance**

According to Singh & Tiong, (2006) contractors' past performance is criteria assess level of expertise offered by contractors in the past project. All the 11 criteria identified in this research based on the measurement of past performance of contractor.

iii. Potential performance

Contractors' performance potential is a category assess experience level and accessibility of assets of the organization in comparable sorts of project (Singh & Tiong, 2006). All the 11 criteria identified in this research based on the measurement of potential performance of contractor.

iv. Multi-criteria

Multi-criteria refer to an evaluation of a multiple criteria rather than price based only. Multi-criteria used in this research are referring to past performance and potential performance criteria.

### **1.10 Organisation of the thesis**

This thesis consists of eight chapters. A summary of each is as follow;

Chapter 1 develops the direction of this research. This chapter describes the research background, research gaps, problems and objectives, scope of the study, research significance, and thesis organisation.

Chapter 2 and 3 identifies the research gaps, which collates the current state of knowledge by reviewing contractor selection models, and different performance measurement concept. Different perspectives of performance measurement in contractor selection construction industry along with existing Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection studies are discussed. This chapter examines the relevant literature to develop Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection model which focuses on past performance and potential performance indicators of the contractor which enables clients to select potential contractor.

Chapter 4 outlines the methodology used to answered research questions. This chapter describes the development of appropriate strategies and approaches,



including the research process used to develop the semi-structured interview questionnaire and model development.

Chapter 5 describes the interview results, survey results analysis and develops a Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection model.

Chapter 6 describes the development of the computerized system for the Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection system prototype by using the specified software.

Chapter 7 shows the validation process of the Flexible Multi-Criteria Integrated Performance-based Decision Model for Contractor Selection system and the prototype. The results and the feedback from the experts are reported in this chapter. This chapter also discuss on the research findings and results.

Chapter 8 concludes the research in terms of the research questions, the contributions and implications of the research. Finally, this chapter addresses some limitations and provides some recommendations for possible future research.

### **1.11 Chapter summary**

This chapter outlines the thesis. It has indicated the research background, current issues of contractor performance measurement and established the research problems and objectives. The research scope and significance were addressed before the thesis organisation was outlined.

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