

POLITECNICO DI TORINO

Master of Engineering and Management



How to measure the performance of megaproject

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Acronyms and Abbreviations:

KPIs: Key Performance Indicators

KPI: Key Performance Indicator

CNKI: Chinese National Knowledge Infrastructure

IPMA: International Project Management Association

PMI: Project Management Association

SMART: S=Specific, M=Measurable, A=Attainable, R=Relevant, T=Time-bound

## How to measure the performance of megaproject

### Abstract

As the development of society and economic, people's increasing demand, people were interested in megaproject since it meet the demands of people, megaproject is a kind of construction work that have a long life cycle, huge amount of work and very large-scale investment, therefore it is necessary to invest a lot of materials, funds, technology and manpower. since how to efficiently measure the usage of all of resources is very important. in the meanwhile, how to maximize the benefit of stakeholders is also important.

Building the performance of megaproject measurement that is a very complex project. it not only involves performance management and evaluation, but also communication problems and incentive methods in the construction process, it is need to use a scientific and reasonable performance model to solve the existing problems and difficulties during construction, and improve the level and quality of megaproject.

Megaproject's performance measurement is important since it determines jobs schedule and works quality. but now it is still in a transitional stage and a new performance model has not yet been established. the traditional "iron triangle" is not suitable for megaproject. for these reasons, in nowadays, the performance model should apply performance management experience according to local conditions.

Therefore, this thesis focuses on the megaproject construction phase, using KPIs method, and taking Shanghai Tower as a case, according to the features of Shanghai Tower to build an efficient performance model, improve the quality of megaproject and stakeholder satisfaction, finally to achieve a win-win situation for all parties.

Key words: megaproject, KPIs, performance model, stakeholder satisfaction, application

# 1. Topic background

## 1.1 Development Status of megaproject

With the development of the economy and more diverse needs, megaproject has a significant increase in academic attention and its growth rate, reaching a peak in the past three decades. the growth rate of megaproject in the next five years is in one. The decline and some stagnant state, until 2016, megaproject growth rate has once again increased slightly, data of development trend is shown in the following figure 1.1.

At the same time, we can see that the growth rate of Chinese literature in megaproject has fluctuated slightly in the past 30 years in China. In other periods, it has shown a steady upward trend. The growth rate of foreign literature in literature has been slightly fluctuating. analysis of this figure shows that megaproject has become more and more prominent in China, and it has gradually grown. However, the growth rate in recent years has not been a steady growth year-on-year, but it has shown a tendency to reverse. The reason is that megaproject has developed in China for a short period of time and is not fully developed. The theoretical basis for measuring performance is not sufficient. The conclusions from practical case are very limited. causing many megaproject' poorly performance has affected megaproject in growth recent years.

In order to solve the measurement problem of poor performance, this paper combines the actual case analysis of megaproject to create a performance model suitable for megaproject, which promotes the continuous development of megaproject while maximizing the benefits for all parties. This is the core of this thesis.

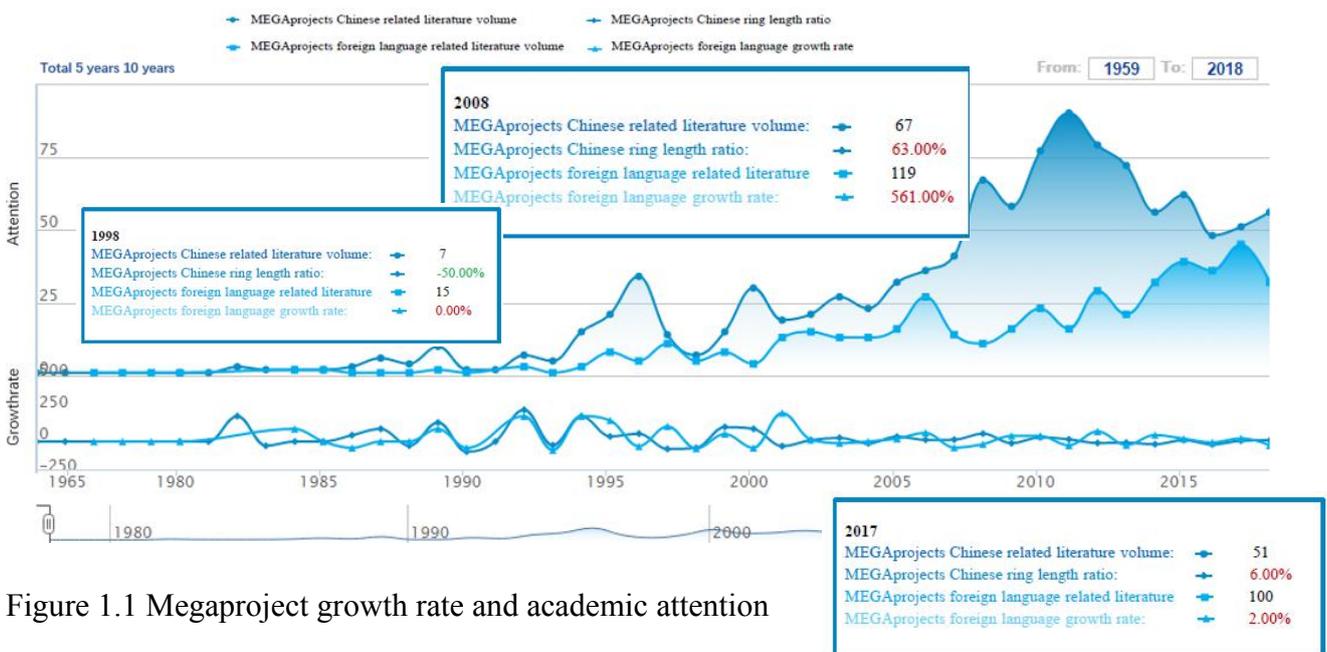


Figure 1.1 Megaproject growth rate and academic attention

Source: CNKI Index

Megaproject have attracted widespread attention from scholars and experts both in academia and the industry<sup>(i ii)</sup>. The past decades have witnessed a great boom of infrastructure investment in China. A large number of world-famous infrastructure mega-projects, such as the Three-Gorges Dam, the Qinghai-Tibet Railway, and the West-to-East Natural Gas Transmission Project, have been successfully built and operated in China <sup>(iii iv v vi)</sup>. Since the Belt and Road Initiative was put forward by Chinese Government in 2013 and the Belt and Road Forum for International Cooperation was successfully held in Hangzhou in 2017, it can be expected that there will be more and more investments in infrastructure mega-projects both in China and in the rest of the world.

The following timeline is some representative megaproject in China.



Figure 1.2 The Time line of China's representative megaproject

Source: CNKI

## 2. Methodology explained illustrate

### 2.2. Research content and significance

#### 2.2.1 Research content and significance

##### 1. Research perspective

This thesis discusses performance management of megaproject which takes Shanghai Tower as a case to build a performance model from the view of the construction side. Due to the project is located in China, this thesis is in view of Chinese regulations. According to "Regulations on the Quality Management of Construction Projects" (Order of the State Council 2000 No. 279) Article 26 stipulates that the construction unit is responsible for the construction quality of the construction project. The construction unit shall establish a quality responsibility system and

determine the project manager, technical director and construction management director of the project. In the case of general contracting of construction projects, the general contracting unit shall be responsible for the quality of all construction projects. Therefore, taking the quality management performance of general contracting enterprises as the research object has a significant effect on improving its quality management capabilities and improving the quality of construction projects.

## 2. The research subject's stage

In megaproject life cycle, it is mainly divided into four parts, the research mainly focus on the construction phase of the project in entire project life cycle, the detail shown as in figure 2.1.

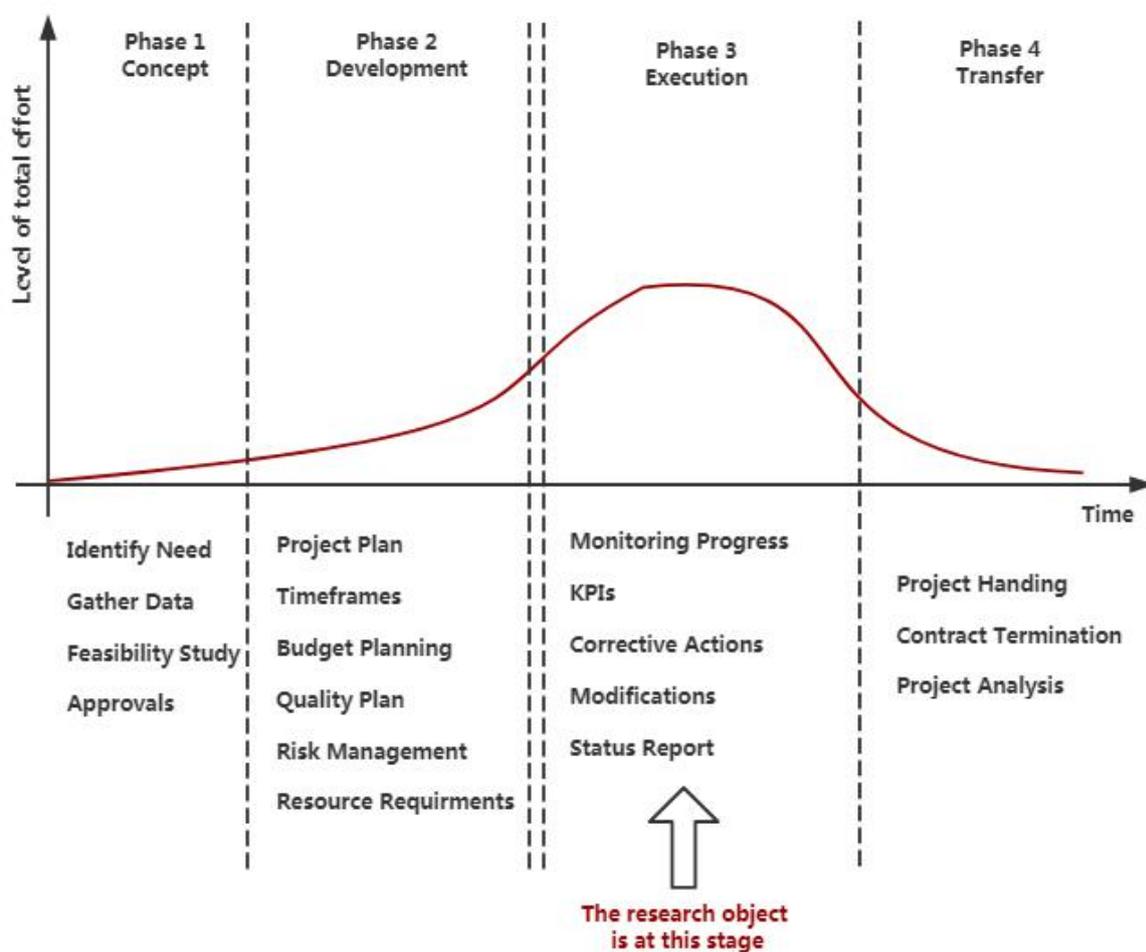


Figure 2.1 The research phase in life cycle

Source: construction life cycle

## 3. Research content

This research is based on the general contractor perspective, from the view of megaproject's KPIs and different quality control points in megaproject process to explores those factors that affect the

performance management level of the construction process and establishes the megaproject performance model. The evaluation model tries to build rational model to improving the performance management level and enterprises' core competitiveness in megaproject .

The main research contents are:

First, it studies the KPIs of megaproject and the problems in performance evaluation. Based on these questions and methods of megaproject management, the thesis will explain different KPIs of megaproject projects, project performance management. it will research from disadvantages of traditional performance management model in megaproject, gradually develop toward a modern theory in megaproject performance management . in the meanwhile the thesis also studies the real application and development process of megaproject performance management. after analysis and research, connecting the process and the case of Shanghai Tower and proposing a useful model for megaproject's performance management.

Second, according to existing problem, the thesis build a appropriate performance model that meets the KPIs of megaproject, and focus on the construction cost, schedule, quality, design, supervision, efficiency, stakeholder satisfaction, etc on the entire process of megaproject management.

Finally, according to the actual KPIs of megaproject, the performance of megaproject evaluation model is built. this thesis focuses on the performance part of megaproject management, analyzes the key elements of megaproject performance management, clarifies the interrelationship between different elements and achieves a good balance, In this way, the performance management activities of megaproject will achieve better results.

The thesis focus on how to build a suitable performance evaluation method during the construction process of an engineering project and establish a KPIs evaluation system that suits the needs of the project. Therefore, this study tries to propose some targeted measures and strategies for project managers in megaproject to inspire theoretically and practically when faced with complex engineering project performance management work, thereby improving the level and efficiency of megaproject performance management.

### 2.2.2 Significance of the study

With the development of the economy and society, in order to meet the needs of the society to expand reproduction and improve the people's living standards, the construction speed of megaproject is accelerating and the market scale is expanding.

In the construction of megaproject, engineering generally requires a large amount of materials, capital, technology and manpower. but how to use all of basic resources reasonably is a very complicated engineering system. That not only involves performance measurement but also

includes evaluation measurement. we can continuously improve and develop the management of megaproject when participants adopting a scientific and reasonable performance measurement management model, to solving the problems and difficulties encountered in the construction process, and improve the construction level and construction quality of megaproject.

Megaproject are unique construction projects known for their complexity, vast size, expensive cost, and long time frame compared to conventional construction projects. megaproject are known for their poor performance in terms of cost and time where the cost overrun could exceed initial project cost and the time extension would extend for years. There are numerous examples of megaproject that were built and performed poorly.

It not only directly determines the construction progress and construction quality of the project, but also strongly influences the healthy development and industry image of the entire megaproject construction field. In this sense, in order to promote the construction of megaproject in an orderly manner, it is necessary to apply scientific performance methods and advanced management concepts, to continuously improve the methods and methods of performance measurement, and to strengthen management tools and techniques. project performance measurement management and evaluation is an important aspect that cannot be ignored. Whether scientific and reasonable performance management methods can be adopted will ultimately determine the orderly operation and engineering quality of megaproject.

So in this thesis, we do a detailed analysis and explain on how to measure the performance of megaproject, to find a solution about how to solve the inefficiently performance problem on expensive cost and waste time, also on the stakeholder satisfaction. This thesis want to find a control method or model can achieve benefit realization in the performance management of megaproject, can get a significant improvement and optimization in all aspects.

The thesis based on KPIs and shareholder satisfaction methods, was used Shanghai Tower as examples to empirically analyze the performance measurement model of megaproject. based on this and in-depth analysis how to improve the performance measurement of megaproject, through conclusion the performance model mechanism was carried out.

Through the analysis of real cases, this study combines theory and practice, tries to extract a new model of megaproject performance measurement, and explores a scientific performance management model for megaproject. Through the promotion and application of research results, it is of great theoretical significance and application value to improve the performance measurement level of megaproject and improve the quality and efficiency of megaproject construction.

## 2.2 Raising research questions

### 2.2.1 Research methods of this thesis

#### 1. Literature review method

This paper uses the literature review method to find out the definitions and specific characteristics of each expert's megaproject, as the initial research content, and on this basis, in-depth study, get the relevant content of owner satisfaction and benefit perception plan. At the same time, the literature review method is still the main method of this paper. Through the use of literature review method to find the focus of problem research and the inadequacies of existing key problems, and through the literature review method to find the existing research methods, thereby defining the research content and selected research methods.

#### 3. Case analysis method

A model for measuring the performance of megaproject was created, and then a case study of three current representative megaproject in China was performed, such as: Shanghai Tower, the work practices retrieved from the case studies.

#### 4. Induction method

Inductive method is a method of individual to general argumentation, which summarizes the common characteristics from individual cases and draws general conclusions. This paper uses the induction method to launch the performance model of megaproject and give a reasonable theoretical analysis.

#### 5. Comparative analysis

Contrastive analysis, also called contrast method or comparative analysis method, is to show the similarities and differences between them through the comparison of actual things. This paper mainly compares the performance methods of megaproject with the general engineering, and draws the similarities and differences between them. Point, to provide a theoretical basis for finding ways to measure the performance of megaproject, and finally create a performance model.

#### 6. Combination of qualitative analysis and quantitative analysis.

In the research and design, this paper combines the needs of research content and purpose, and combines literature research with case analysis to make data analysis and qualitative judgment.

#### 7. Replicating choose method

Through the research on the performance factors of the basis of Megaprojects, the performance factors of Megaprojects in each article are counted and selected, and the main performance factors of current shareholders are identified. The main content of this paper is to summarize the shareholders, Sensitive points of the benefit realization plan.

#### 8. Consultant and experience conclusion

From experienced senior or supervisor, discuss and communicate with them, consult previous megaproject experience. absorb the knowledge and advice, through conclusion, write in survey sheet.

#### 2.2.2 Questionnaire in megaproject

According to “hot issue” of megaproject, the thesis designing a questionnaire of megaproject performance measurement. In addition, in this character it is clearly stated why the thesis choose these project samples, where is the data set come from, and how to identify and conclude the focus research content in the thesis. the following will explain in detail:

#### **Why the thesis choosing these project samples:**

First, these selected samples all of are large-scale infrastructure construction projects in China, the selected samples all of are magaprojects, maybe they are not landmark buildings, but it is must be large-scale. for example: some residential or high-rise commercial buildings, or large-scale underground construction projects.

Second, they are high degree of similarity with magaproject features, such as: Long life cycle, huge cost, various of stakeholders satisfaction, complicated contracts, or poor-performance measurement, etc.

Third, because all of these megaprojects have been completed, through the questionnaire survey of management staff or technical staff, we can summarize existing problems.

And last, all of megaproject are coming from china, due to different country has different national conditions, legal systems, environments and so on. meanwhile, this thesis is mainly based on China's megaproject. if sample are selected from China, which is more suitable for application, and the research will be more convincing.

#### **How to contact with managers: 3 aspects**

Due to I am undergraduate TianJin Technology University, the major the engineering cost, i know a lot senior researchers when i follow my supervisor to completed bachelor thesis, and now one of them is working in Jinan, Shandong, China Construction eighth engineering division, the position is

project manager, i asked him to help me distribute 20 questionnaires to the relevant technical staff and project managers who had participated in the some megaproject, through around 7 days, recovered 18 questionnaires. and in this questionnaire research most involved megaproject are Nanning center (357m) and ZhouDaFu finance center (530m).

The another senior is working in JianYe Luoyang, HeNan, central china real estate limited, this company is mainly worked for high-rise real estate, For example: JianYe.J18 and JianYe.Spring etc. i asked him to help me distribute 15 questionnaires to the relevant technical staff and project managers who had participated in some high-rise real estate megaproject, through around 7-9 days, totally recovered 13 questionnaires.

My bachelor graduation internship is in cost engineering consultant company (Real estate consultant (Tianjin) co. LTD)vii, this company has participated many megaproject cost quotations, consulting and life cycle management. They have rich practical cases experience. in this company my position is the Survey Engineer Assistant, during the internship, i established a good relationship with colleagues, i thought if i contact with my previous colleague they help will valuable for this thesis. so I contacted with my previous colleague, now he is a project manager in this company and he help me distributed 10 questionnaires sheet on WeChat group, covered for technical staff and project manager who have participated in magaproject. Around one week, a total of 9 were recovered.

### **How to identify the questionnaire content: 3 aspects**

I did a literature analysis (mentioned above: repeating choose method) by reading some academic articles on IPPCE, and design the questionnaire mainly from the frequency of research, if there are a lot of people public related articles included key performance indicators, this questionnaire will not include in these kinds of questions, but if it is rarely research, and also have great space need to improve, and in the future if company improve these area that will get great competitive advantage, the questionnaire will involve it.

IPPCE is institute of public project & engineering in TianJin Technology University, there are so many researchers participated Guangzhou underground construction project or the construction project of BeiJing underground line 4, they are very experienced in such magaproject, my bachelor thesis is completed here, so I know with some researchers in IPPCE, through we communicate with these researchers and discuss, they gave me documents aabout maga-construction project and gave me some advice and experience on design magaproject performance questionnaire.

In the IPPCE think tank, there are so many real-time research of the latest engineering consulting project that is useful for me to analyze existing megaproject performance problemsviii.

Through above three aspects to summary, find the causes of megaproject under-performance, through analysis, the causes of under-performance are mainly existing in following aspects:

1. Efficiency performance measurement system;
2. Organization performance, build a efficiency incentive mechanism is important;
3. Identify employees self-evaluation is more optimized, increase communication and feedback between project managers and employees, link compensation management with performance measurement.

Through these aspects, the questionnaire is designed.

This questionnaire mainly use muti-choice, the detail show as table 2.1.

Table 2.1 Project Performance Management Questionnaire

First part: Overall evaluation of the performance measurement system	
Overall evaluation of performance measurement system	1. Do you think the performance measurement of megaproject is comprehensive and systematic? Very scientific and reasonable More scientific and reasonable Not scientific and reasonable Uncertain
	2. Do you think the performance measurement of megaproject is reasonable and it can reflect the real performance situations? Very effective Effective No effect Uncertain
	Do you think the performance measurement of megaproject is clear and easy to implement? Strongly operable Operability

Not operability

Uncertain

3. Do you think the results of megaproject performance measurement are clear and easy to improve?

Strongly agree

Agree

Disagree

Uncertain

### Second part: Evaluation of the organization's performance

5. What do you think of the weight of megaproject performance indicators, evaluation criteria of megaproject?

Very scientific and reasonable

Reasonable

Not scientific and needs improvement

Uncertain

6. Do you think it is reasonable to use self-evaluation or supervisory assessment as the main evaluation principle?

Very scientific and reasonable

Reasonable

Not scientific and needs improvement

Uncertain

7. What extent do you think good work performance is due to good internal and external communication:

More than 50%

Around 30%

Around 10%

Unrelated

8. Is there good communication between the project managers and staff?

Good communication

Have some communication

No communication

Evaluation of the organization's performance

Uncertain

9. Do you think that linking the evaluation results of the project team with the personal bonus, the employees' recognition:

More than 80%

Only 50%

Only 30%

Very disapproved

10. Satisfaction of the project manager's emphasis on performance management and improvement efforts is:

Very satisfied

Quite satisfied

Not satisfied

uncertain

11. Has performance measurement management become an effective management tool for continuous improvement of the organization?

Yes

No

uncertain

12. The content of performance measurement, its formation process is:

Determined by management and employees in advance

Proposed by employees themselves and confirmed by managers

Prepared by managers for employees

uncertain

13. Your evaluation of the motivation of the company's current performance measurement system for employees is:

Very strong incentive

Strong motivation

Lack of motivation

very bad

14. What do you think of the company's work in this area since the implementation of

performance measurement management:

Very effective

Effective

No effect

Uncertain

15. Is the current cycle of annual employee assessment appropriate?

Very suitable

More suitable

Very inappropriate, keep adjusting

Uncertain

### Third part: Evaluation of employee performance

16. Your evaluation of the fairness and fairness of the current performance measurement management system is:

Very fair

Fairer

Not fair enough

Uncertain

17. Performance feedback, the project manager's approach is:

Feedback and communication every time

Sometimes feedback and communication

Never feedback

Uncertain

18. Does the performance measurement system's evaluation of employee performance allow you to achieve continuous improvement more effectively?

Exactly like this

Sometimes it 's like this

Not necessarily so

Not at all

Evaluation of employee performance

19. The relationship between your compensation and performance management is:

Strong correlation

Generally relevant

Weak correlation

Irrelevant

20. In your opinion, when managers evaluate the performance of employees:

Very objective and fair, based on a large amount of data and information

More objective and fair, with certain data and information more subjective

Evaluation based on impressions and feelings is very subjective and knows very little about the actual situation

Source: conclusion from consulting method and replicating choose method

After the questionnaire, I found most megaproject participants have a low agree on the current the performance model. I analysis the result from following aspects: overall, organization performance and individual performance.

In overall evaluation, 66% thought it unsystematic, 78% thought KPIs are not objective enough to reasonably evaluate and reflect job performance, 67% thought this model have poor operability, it is not very suitable for megaproject daily operating. 71% thought the effect of performance model is not obvious, no improvement in actual work.

In organization performance evaluation part, the data show most of employees dissatisfied with manager's attention and execution, and it has not been "an effective performance measurement tool for improvement of organization". more than 70% disagree with "project managers dominate over employees" in evaluation process, and thought that need to optimize, 78% agree with link the performance result with subsidy. for the content of performance evaluation part, almost agrees that can be made by project managers. for incentive part, nearly 80% thought the effect is poor.

In employees performance evaluation part. most of employees thought the period of annual performance measurement is very inappropriate, it is should carry out whole life cycle performance measurement. 89% though project managers never communicate with the performance results, 73% thought performance measurement has little affect to compensation , even 21% thought that is completely irrelevant. 83% thought project manager's evaluation of employees is subjective and basically based on impressions, and 13% thought that is very subjective, even known little about actual performance situation.

From the analysis, as can be seen, so many megaproject performance model are still too simple, not systematic enough, not comprehensive and reasonable to evaluate and reflect real performance situation, the operability of performance measurement is weak, not applied to daily work. communication and feedback mechanism are not applied to team work, meanwhile, project managers do not paying enough attention to performance measurement and do not using it as a efficiency tool to improve megaproject performance. therefore, we should improve the megaproject performance measurement systematically.

So firstly, we can no longer be simply thought performance measurement equated to performance assessment.

Secondly, megaproject performance measurement can not only be a form, and measurement ways are too simple, lack of feedback and communication.

Lastly, can not lack effective incentive mechanism.

According analysis all of existing problems advantages and disadvantages, it is can help this thesis to build more optimize megaproject performance model.

The more detail will show in chapter 1.2.3. existing problem in megaproject

### 2.2.3 Analysis of existing problems

Megaproject measurement process still exists a series of problems need to be further improved, such as lack of communication and communication in the performance measurement, no corresponding feedback during evaluation, and insignificant performance effects. these problems are summarized as figure 2.2.

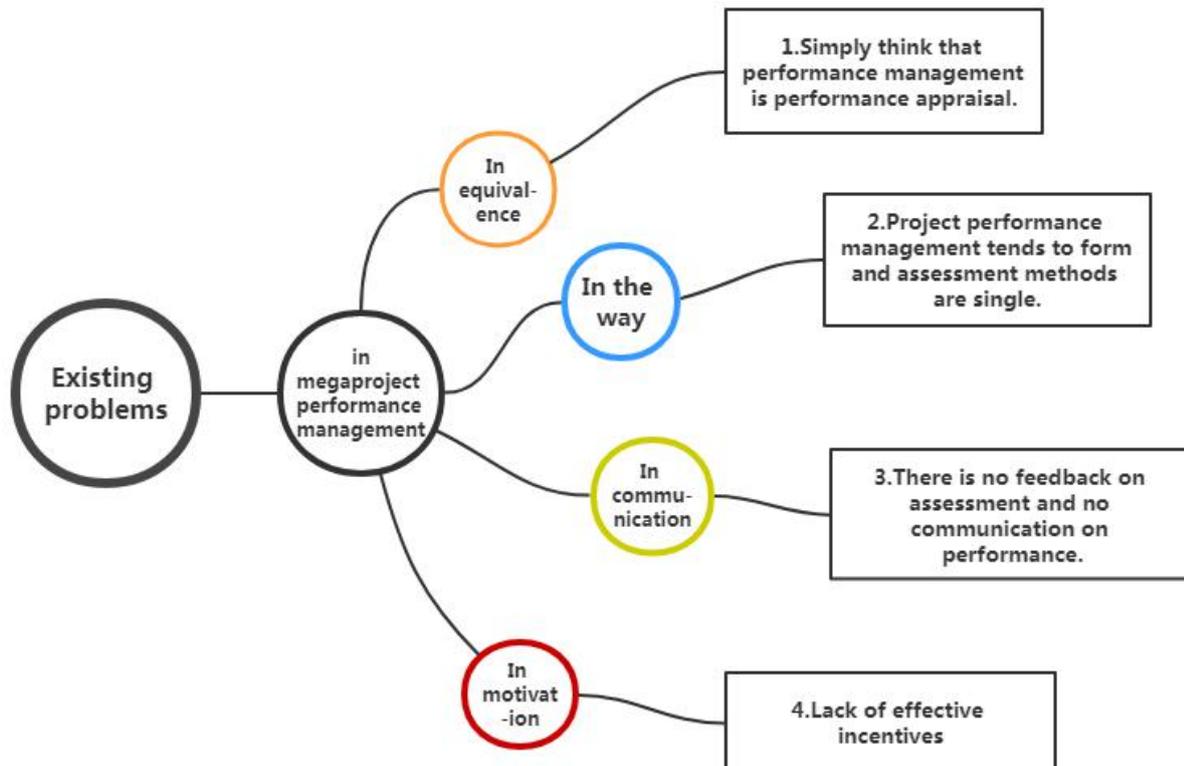


Figure 2.2 Conclusion existing problems in megaproject performance management

Source: analysis the questionnaire results

1. Simply thought performance measurement is performance assessment.

Firstly, it is need to distinguish performance measurement and performance assessment. performance measurement is a way that can promote teams or individual make action that are good for achieving organization goals by continuous communication and continuous feedback. in addition, performance measurement in order to achieving goals that is improved the performance of employees, departments and organization by planning, organization, command, coordination and control.

Performance assessment is a measurement systems that focuses on ex-post evaluation. the mainly evaluation aspect are: work content of employees, and work results inspection and performance measurement. performance assessment can be regarded as a key part of performance measurement, but it cannot be equated with performance measurement.

When performing performance management, original performance model simply quantified megaproject performance measurement and used the form of performance assessment sheet to show performance measurement. this approach simply assumes that performance measurement only uses

contents of assessment sheet. without considering other factors, such as: stakeholder satisfaction, benefit realization, communication, feedback, measurement period and so on. original performance model only implemented at the end of the year, and it was not comprehensive. in other words, it is not only lack performance management awareness among project managers, but also lack the training of employees in this aspects.

Due to above problems, project managers do not have enough specific KPIs when measuring performance, leading to poor performance measurement of megaproject. as a result, the performance model cannot to use constrain and control employees, to achieve optimal resource allocation and efficient results, so we must essentially distinguish between performance measurement and performance assessment.

2. Project performance measurement tend to a form and measurement ways are too single, lack communication and feedback.

The original megaproject performance measurement method is usually filling out the performance sheet, and the performance sheet often refer to the goals set at the beginning of the year, the performance sheet lead to obtain employee's performance score, and then evaluate the performance of megaproject. but in this method, performance measurement process has been simplified, making it difficult to comprehensively measure employee performance. in additional, in this kind of methods, the goals are set by project managers, without communication with employees (the questionnaire results show that 89% of employees thought that project managers have not provided feedback and communication), in this situation, the communication of the organization is blocked, there are not efficient communication. so these have led to the formalization of performance measurement, and lack of credibility.

However, it is important to note that performance measurement cannot exist without communication. the work of each employee is inseparable from the communication and support of teams and other members.

Therefore, the "similarity" of KPIs for performance measurement has made it untargeted and not applicable to all types of employees, making employees lack confidence, since they do not pay enough attention and treat them negatively, finally due to poor performance in megaproject.

In conclusion, in megaproject performance measurement, in order to ensure megaproject goals and increase the passion of employees for performance measurement, project team should be more closely coordinated with individual that not only include vertical communication, but also horizontal communication and consultation with other department. at the same time, different

assessment target should be customized for different types of performance measurement. consider a more comprehensive and targeted performance model, do not limit it to one performance measurement method.

### 3. Lack of effective incentives

In megaproject performance measurement process, the purpose of megaproject performance measurement is to promote employees' thinking innovation and initiative. the results of questionnaire showed that nearly 80% of employees felt that the original performance measurement model could not provide incentive, whether in terms of physical incentive or spiritual incentive.

In physical incentive, there are some problems, such as: similar compensation level, and it can not reflect employee real contributions in megaproject since it is little connection between compensation and performance measurement. moreover, performance is not an actual measurement, like a kind of bureaucracy that must be completed and so on.

In spiritual incentive, the questionnaire results showed that nearly 90% of project managers did not know actual situation in depth, but made evaluations based on impressions, thus losing the authenticity of the performance measurement, which led many employees thought “good relationship is more important than job performance” and ignore actual work. it is will not help the company's long-term development and achieve goal.

The improved megaproject performance model should be able to reflect the difference of contribution, and select excellent "benchmarks" as incentives to achieve a better megaproject performance.

Through analysis these existing problems, there are very clearly show some area need to improve in the megaproject performance measurement model. in the next chapter, it is will explain in detail how to improve the megaproject performance measurement.

## 2.3 Technical route and method

### 2.3.2 Route of research

1. First of all, this thesis talk about the background of magaproject, also discuss how and why it develop so fast in China in recently years. as it develops, researchers and people pay more attention to this area, at the same time, lots of megaproject problem arise.

2. Second step is methodology explained illustrate phasem totally it is includes 3 steps: A: identify research phase and significant, B: raising research question. C: the basis of all research questions:

literature review, but for clarity, this thesis take the literature review as a independent chapter 3, but it is essentially belong to methodology explained illustrate.

A: Firstly, it is to identify research phase and significant, used literature analysis method and consultant method.

During research process, i found that so many construction enterprises have overspend budget, delayed schedule, and some other problems, why this happened, mostly due to long time poorly performance control and measure, there is not a suitable magaproject performance model, therefore, to build a efficient magaproject performance model is so necessary, it not only solve magaproject existing problems, but also improve construction enterprises competitive advantage and project efficiency, try to best to achieve stakeholder satisfaction.

Meanwhile, through consulted some experienced technicians and project managers who have participated magaproject in China, used consulting method, to identify research phase in magaproject life cycle. we found that the problem frequently arise phase is the construction stage. Therefore, in this article, we focus on construction phases.

B: second step, it is to raise research questions, used literature replicating choose method to find what key performance indicators are researchers pay less attention to, but it is so important for magaproject measurement. and then, took the result to consult experienced project managers advice, combined both to design the magaproject performance questionnaire. and at last, through analyzes these feedback of questionnaire, arised these three questions (improve the performance model, establish KPI and identify weight) that need to solve in the magaproject performance measurement.

C: chapter 3: litreature review, gather all of research result and consult experienced megaproject managers and technical staff, analysis literature.

3. Third step, defined performance concept and project performance concept that will as the basis for improve magaproject performance model. and then compared advantage and disadvantage of different megaproject performance measurement, meanwhile consulted experienced technical staff and project managers to build a more optimized magaproject performance model, this model used for solve above arise questions: optimized magaproject performance model, build KPIs and weight of indicators.

4. Application this improved performance model to Shanghai Tower

5. Look for future and conclusion

The research route of this paper is shown in figure 2.3.

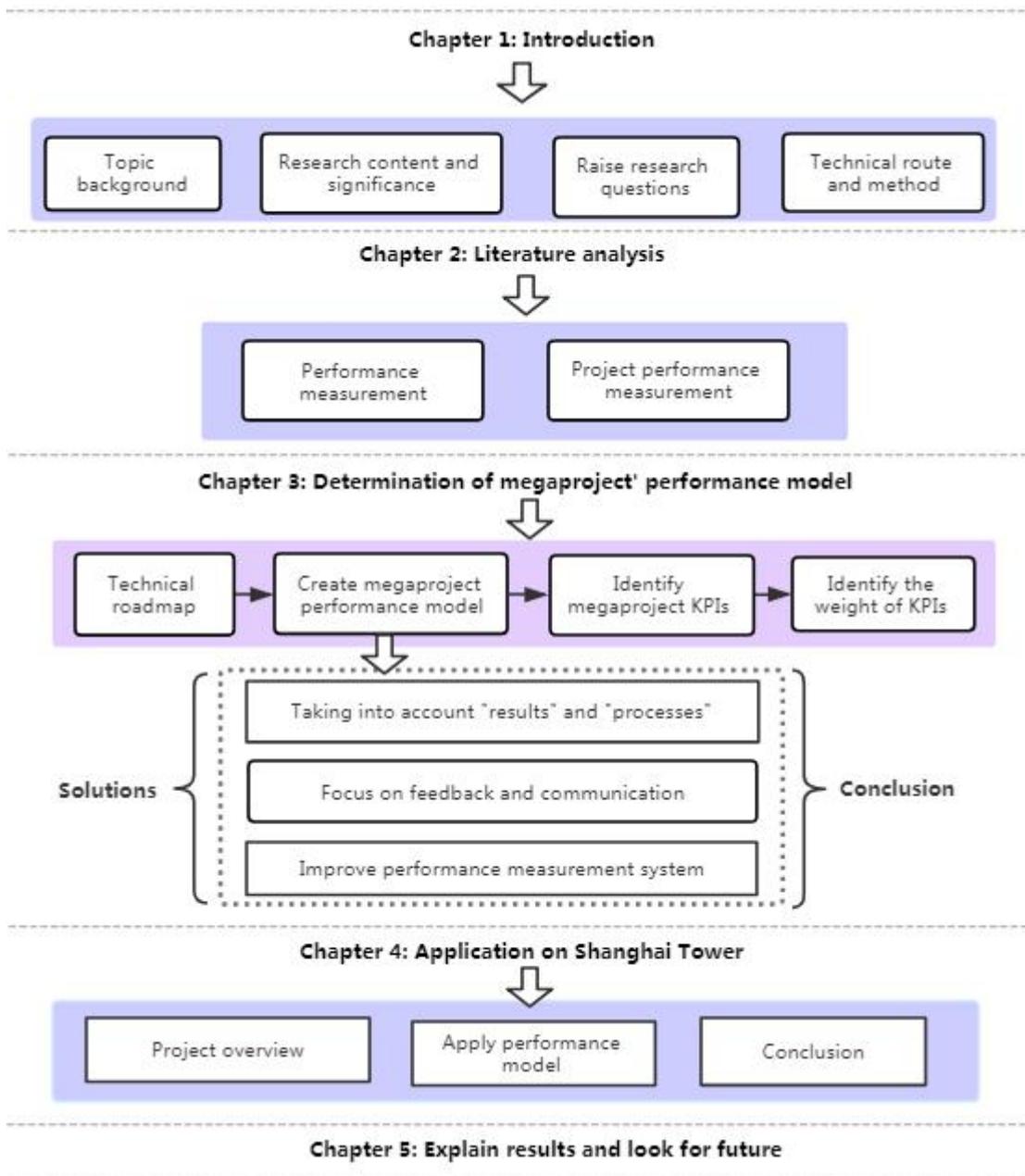


Figure 2.3 Route of thesis

Resource: conclusion from whole paper

### 3.Literature Analysis

Chapter 2 is the basis of the whole paper and integrates all literature review. for clarity, it is summarized as Chapter 2, and how to use the literature in each section is explained in detail in each section.

### 3.1 Overview of Megaprojects

#### 3.1.1 Basic definition of Megaprojects

Megaprojects are large, complex, and expensive projects that often result in undesired outcomes with enormous cost overruns and time extensions. Megaprojects have been studied in many academic areas such as public planning, urban decision making, and economic analysis areas. They have been analyzed as complex hard to finance projects with economic gain and social impact. Limited research has been done in the construction industry to investigate Megaprojects and to improve their performance. This research defines Megaprojects in their construction management context. It analyzes their characteristics that cause time and cost overruns. Finally, it attempts to improve Megaprojects poor performance by presenting a set of work practices that were applied on different Megaprojects<sup>ix</sup>.

there is no definite understanding of what differentiations from any other large or complex project. The only common agreement among practitioners and researchers is the concept of a large scale project with a price Tag in excess of one billion dollar (Fiori et al. 2005<sup>x</sup>), that frequently leads to cost overruns (Flyvbjerg et al. 2003<sup>xi</sup>).

Capka (2004)<sup>xi</sup> defines Megaprojects as expensive projects that require the management of numerous, concurrent, and complex activities while maintaining tough schedules and tight budgets. More elaborate definitions describe Megaprojects as large scale complex projects that often fail to meet costs estimations, time schedules, and anticipated project outcomes.

Other definitions describe Megaprojects as projects that contain a large element of technological innovation associated with high risk and characterized by conflict, uncertainty, and poor cooperation between partners (Marrewijk et al. 2008<sup>xii</sup>).

According to the Oxford Handbook of Megaprojects Management, "Megaprojects are large-scale, complex, take many years to develop and build, involve multiple public and private stakeholders are transformational, and impact millions of people"<sup>xiii</sup>.

Therefore, a more general definition is "Megaprojects are temporary endeavours (i.e. projects) characterized by: large investment commitment, vast complexity (especially in organizational terms), and long-lasting impact on the economy, the environment, and society"<sup>xiv</sup>.

#### 3.1.2 Feature Analysis of Megaproject

According to the European Cooperation in Science and Technology (COST), Megaprojects are characterized both by "extreme complexity (both in technical and human terms) and by a long record of poor delivery"<sup>xv</sup>.

Megaproject attract a lot of public attention because of substantial impacts on communities, environment, and budgets, and the high costs involved<sup>xvi</sup>.

Megaproject can also be defined as "initiatives that are physical, very expensive, and public"<sup>xvii</sup>.

Megaproject are often affected by corruption leading to higher cost and lower benefit<sup>xviii</sup>.

Megaproject are unique construction projects known for their complexity, vast size, expensive cost, and long time frame compared to conventional construction projects. The size and complexity are reflected by a price tag that exceeds one billion dollar and by a time frame that may exceed the five year limit.

Megaproject are known for their poor performance in terms of cost and time where the cost overrun could exceed initial project cost and the time extension would extend for years.

In conclusion, megaproject is complexity, huge size, long life, very expensive and always overrun cost.

### 3.2 The overview of megaproject KPIs

#### 3.2.1 Identify what KPIs is being studied

if we want to find a efficiently performance model for megaproject.

The first step, it is need to know what key performance indicators is used, the thesis uses consulting method to obtain some KPIs mainly involved in megaproject from some experienced people.

And then it is need to know what is the "hot research points" of megaproject performance measurement. firstly, in the Scholar.Google and CNKI, search the key words "performance measurement of magaprojects", found 13 related articles. and then, used literature replicating choose method to find what key performance indicators are researchers "hot focus". show as the table 3.1.

The third step is to compare the first step with the second step, it is can drive results what key performance indicators are researchers pay less attention to, but it is so important for magaproject measurement. and then build a more complete model.

Table 3.1 “hot research points” of megaprojects performance factors

KPI scholar	KPI 1	KPI 2	KPI 3	KPI 4	KPI 5	KPI 6	KPI 7	KPI 8
	Safety	Time	Meet Budget	Qualit y	Organize communicate (Efficiency executive)	Incentive	Employee performance	Performance system
Cox et al. <sup>xix</sup>		√	√	√			√	
Shamas-ur-Rehman Toora, Stephen O.Ogunlana <sup>xx</sup>	√	√	√	√				
Atkinson <sup>xxiv</sup>		√	√	√				
Toor and Ogunlana <sup>xxvixxxvii</sup>	√	√	√	√	√		√	
Turner <sup>xxix</sup>	√	√	√	√	√		√	
Westerveld <sup>xxx</sup>	√	√	√	√	√		√	
Pinto and Slevin <sup>xxxi</sup>	√	√	√	√	√		√	
Bryde and Brown <sup>xxviii</sup>	√	√	√	√	√	√	√	
Belout and Gauvreau <sup>xxxii</sup>	√				√		√	
Freeman and Beale <sup>xxxiii</sup>	√	√	√	√	√		√	√
Norrie and Walker <sup>xxxiv</sup>	√	√	√	√	√		√	√
Shenhar <sup>xxxv</sup>		√	√	√	√		√	
Yin YiLing <sup>viii</sup>	√	√	√	√	√			√

Source: Scholar.Google, CNKI and IPPCE think tank

### 3.2.2 Identify the KPIs needed for this thesis

It is found that they researched mainly focus on project time, cost, quality and safety. in contrast, megaproject performance system, incentive mechanism and organization management are relatively less involved. However if we want to achieve a good performance of megaproject, megaproject performance system, incentive mechanism and organization management are essential key performance factors, it is not only help improve megaproject efficiency, but also improve construction company competitive advantage, improve performance system.

So in this thesis, it is mainly focus on organization performance, incentive, megaproject performance mechanism that those are rarely covered by existing research.

### 3.3 Overview of megaproject performance measurement

In the 1960s, the International Project Management Association (IPMA) was born, it was the first professional project management agency, and since then, a new American Project Management Association (PMI) has been established. as time goes by, these international organizations driven by the project management professionals, they understand the importance and significance of project management has been deepened. In the context of economic globalization and the transnational nature of many projects, the current project management has obvious international characteristics, and has gradually formed a comprehensive international common system and international practices. With the help of information technology and electronic technology, project management can rely on computer software to operate that more efficient and convenient, and has realized networking and automation. Otherwise in quality management, risk management, communication management, and information management have become hot areas. the knowledge system of project management is becoming more and more abundant, enabling project management to meet customer needs to the greatest extent and achieve benefit realization<sup>xxi</sup>. With the status of project management in economic and social life more and more important, topics such as project management, quality management, and risk management have increasingly attracted the attention of the academic community and become a hot topic of research. For the academic literature on megaproject performance measurement management, the author is divided into the following three aspects to sort out and evaluate:

### 3.3.1 Research on performance measurement

If we want a good project performance measurement, the first necessary step is to understand what the performance is. there are three main points about what performance is, show as figure 3.1:



Figure 3.1 What is performance

Source: literature analysis conclusion

The first view is that "performance is a result." Many scholars hold this view. For example: Kane (1996) believes that performance is the social creation of individuals.<sup>xxii</sup> Bernardin (1995) argues that performance is a record of a particular work output over a certain period of time.<sup>xxiii</sup> These scholars understand performance as a result, in line with people's daily feelings, and facilitate the evaluation of performance. They believe that the effect achieved by personal work, that is, work performance, is performance. Goals, tasks, indicators, outputs, and responsibilities are all performance-related concepts and factors that measure performance. "Performance is a result", so that when we evaluate performance, we can use specific indicators such as cost and output, which are operational and objective<sup>xxiv</sup>.

The second view is that "performance is a behavior." Representative scholars who hold this view are Campell (1993) and Borman Motowidlo (1993). Campell believes that performance is the ability to measure individual abilities and personal behavior, and they are related to organizational goals. According to Borman Motowidlo, performance includes task performance and relationship

performance. The behavior required by the work objectives is task performance; the behaviors unrelated to the work are relationship performance. Task performance and relationship performance constitute a two-dimensional model of performance. The idea that performance is an act is that the behavior associated with a given task is itself performance. This view shows that<sup>xxv</sup>: first, the results of work are affected by procedural factors and interpersonal factors, so the individual behavior of employees does not necessarily determine the outcome of the work; second, the performance of employees is not necessarily related to the work objectives; third, not each Employees have equal opportunities to achieve their work goals. Fourth, the evaluation orientation of outcomeism tends to induce short-term behavior of employees, such as the pursuit of immediate interests.

The third view is that "performance is both behavior and result." Behavior and outcome are two aspects of performance, and they are interrelated. The representative of this view is Brumbrach. Brumbrach (1998) argues that behavior is the performance of an individual's work, and the result is the individual's work effect. When an individual puts a work task into practice, there are both work performance and work effect. In this sense, behavior and outcome are two indispensable components of performance<sup>xxvi</sup>.

Individuals have to pay physical strength, brain power and money in the course of their work in order to produce corresponding results. Therefore, regardless of the final result, this behavioral process itself is a result. Therefore, in actual work, we evaluate a person's work performance, and must consider the two levels of behavior and results. On the one hand, we must examine the individual's contribution that is behavior, and on the other hand, measure the individual's output that is the result.

In academia, the concept of performance management is also widely debated and controversial. Representatives include Ainsworth, Smith, Heisler, Quinn and Hall<sup>xxvii</sup>. For most researchers, performance management encompasses multiple aspects, not only managing organizational performance, but also managing employee performance. It is mainly divided into three stages: the planning stage of organizational goals and strategies; the improvement stage of task implementation and quality management; and the evaluation stage of performance evaluation<sup>xxviii</sup>.

In short, we can only conduct targeted performance measurement for specific activity objectives and organizational members in a certain organizational structure. In other words, organizations and individuals, and the various levels between them, are the scope of performance management<sup>xxix</sup>.

Therefore, performance management involves multiple levels, not only considering the individual needs of employees, but also focusing on organizational goals and tasks. Only by combining the

work behavior of employees with the mission of the entire organization can the goal of performance management be achieved.

### 3.3.2 Research on project performance measurement

The performance measurement of engineering projects is closely related to the objectives and tasks of engineering projects. The international academic community has done a lot of research on the content, meaning and indicators of project performance measurement, a brief review is as follows Figure 3.2:

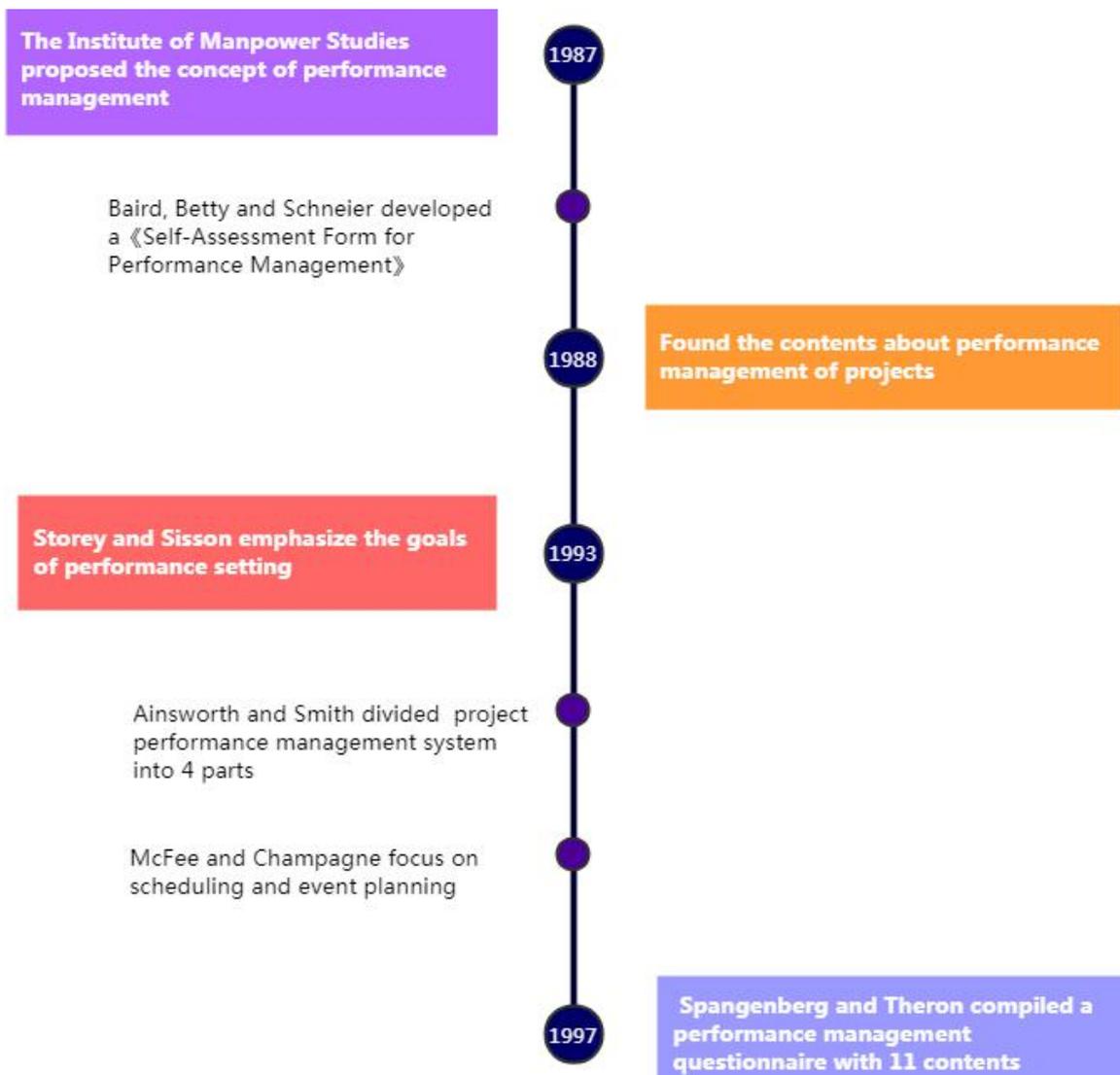


Figure 3.2 Milestones of Project performance measurement

Source: literature review conclusion

In 1987, the Institute of Manpower Studies in the UK proposed the concept of performance management. It believes that performance plans, stage objectives, setting employee performance standards, employee identification and commitment, employee performance evaluation, formal

performance evaluation and performance allowance are all performance management in the implementation of projects<sup>xxx</sup>. Therefore, according to the progress of the project, the content of performance management is also changing. Still others have proposed a cyclical view of performance management. Craig Eric Schneier, Richard W. Beatty, and Lloyds S. Baird (1988) based on experience research found that performance management of engineering projects includes:

The setting of performance standards, the achievement of contractual relationships, the planning, execution, supervision, control, evaluation, results feedback and improvement of performance management, optimization of management strategies, and so on, constitute a complete cycle.

According to the construction needs of the project, Ainsworth and Smith (1993) divided the performance management system of the project into three parts, including: performance plan, performance expectation and performance feedback and optimization<sup>xxxii</sup>. Unlike Ainsworth and Smith, McFee and Champagne (1993) focus on scheduling and event planning in performance measurement, and sees performance planning, performance management, and performance evaluation as part of a performance management system<sup>xxxiii</sup>. Storey and Sisson (1993) emphasize the goals of performance setting. Based on the performance goal setting process, they divide performance management into five parts: organizational goals, stakeholder goals, performance measurement, performance rewards, and performance management optimization<sup>xxxiii</sup>. Each of the above scholars is based on their own position, combined with the management of the project, put forward the level and content of performance management, each with its own focus<sup>xxxiv</sup>.

In order to meet the needs of the development of the market economy, developed countries attach great importance to the performance measurement of engineering projects, and they introduced performance management to the construction of the project very early. Combined with the actual needs of the construction project, the scholars compiled a comprehensive and systematic questionnaire to investigate the performance of the project. In 1987, researchers Baird, Betty and Schneier establish a 《Self-Assessment Form for Performance Management》 that with 39 elements, and the project manager examined and examined the performance measurement status of the project<sup>xxxv</sup>. On their basis, in 1997, Spangenberg and Theron compiled a performance management questionnaire with 11 contents<sup>xxxvi</sup>. The questionnaire is very complex and involves a lot of content, including academic literature research, in-depth interviews, and questionnaire surveys. The three main components include the establishment of organizational goals, the planning of team tasks, the goals of team members, the driving of organizational strategy, the design of organizational structure and the management of organizational performance, performance feedback, performance incentives and so on.<sup>xxxvii</sup> Incorporate all aspects of the project into the performance measurement system.

### 3.3.3 Compare pros and cons of megaproject performance

There are many methods for megaproject performance measurement, each method have different definition, purpose, advantages and disadvantages. therefore, the construction enterprise of megaproject should choose the evaluation method for performance measurement according to its own situation. in general, megaproject performance evaluation methods can be divided into behavior level (work expression) and results level (work performance).

Behavior as a performance measurement criterion is based on the assumption that certain behaviors will produce certain work results and that certain jobs should produce certain types of behaviors. using work behavioral performance as a performance measurement standard can help evaluate more complex project execution, connect actual performance to work performance, control costs, improve efficiency, and further clarify the role and location of each employee.

The result-oriented performance evaluation method is the target management method. targets management method is that each employee and manger set future performance targets together. these goals should be consistent with each other and can be objectively measured. because employees participate in setting targets, they willing to achieve them.

The specific definition, advantages and disadvantages of kinds of evaluation methods are shown in the table 3.2.

Table 3.2 compared with different kinds of megaproject performance measurement

Performance methods	Definition	Advantage	Disadvantage
Evaluation rules method	Evaluators score and sum according to evaluate factors and standards (The score is expressed as: A, B, C, D,E or 1,2, 3, 4).	<ol style="list-style-type: none"> <li>1. Easy to design and understand, economic.</li> <li>2. There are some clear scopes or scores to follow, avoid dispute.</li> <li>3. Use sum way to get results, fair and accurate.</li> </ol>	<ol style="list-style-type: none"> <li>1. Assessors are affect by subjective factors.</li> <li>2. Different score standard by different people.</li> <li>3. Evaluation sheet is difficult to meet all of features of assessed.</li> </ol>
Evaluation sheet method	According the words describe of employees behavior, evaluators check behaviors one by one, finally each indicator is summed or averaged according to different weights or scores.	<ol style="list-style-type: none"> <li>1. It is easy to judge behavior is or not.</li> <li>2. Evaluators do not need extra train.</li> <li>3. Evaluators only need to assess reality.</li> </ol>	<ol style="list-style-type: none"> <li>1. It is difficult to analysis and sort out.</li> <li>2. Different works need different evaluate sheet.</li> <li>3. Evaluation depend on evaluators impress that lack truth.</li> </ol>
Forced selection method	Make a select from double situations to avoid mistake, double situation both are negative or positive describe.	<ol style="list-style-type: none"> <li>1. Reduce prejudice.</li> <li>2. Contents and scores are very strict.</li> <li>3. Suitable for changeable works.</li> </ol>	<ol style="list-style-type: none"> <li>1. It is difficult to get feedback.</li> <li>2. It is hard to design the title or options.</li> </ol>
Important case method	Evaluators record important events in daily work and integrate as data cards, according data cards to measure the performance and behavior of employees when annual evaluation.	<ol style="list-style-type: none"> <li>1. Give a feedback of works.</li> <li>2. Provide true facts to managers as a reference to train employees.</li> </ol>	<ol style="list-style-type: none"> <li>1. To making data cards that need a lot of time.</li> <li>2. The time of evaluation also will increase.</li> </ol>
Targets management method	According to the work items asked by manager, employees communicate with manager, defined work scope, work steps and standards together.	<ol style="list-style-type: none"> <li>1. Use target management method to incentive employees behaviors.</li> <li>2. Performance measurement is very clear.</li> </ol>	<ol style="list-style-type: none"> <li>1. It is hard to decide target level.</li> <li>2. Sometime, target achieve is depend on environment.</li> </ol>

Data resource: draw by yourself

In this study, by considering the management required of megaproject, advantages and disadvantages of different kinds of performance measurement methods, to build a set of suit for

construction company performance measurement methods, which combines the advantage of target management method and evaluation sheet method, effectively achieve the purpose of performance measurement.

#### 4. Determination of megaproject' performance model

##### 4.1 Technical roadmap for megaproject performance model

There is a technical roadmap for how to improve megaproject performance measurement, through the definition, features, and compared cons and pros of megaproject measurement model, consulting some experienced project managers and doing some literature review, and then analysis all the materials, identified research problems. in this chapter, it is need solve this problems, show as follow.

1. In response to the above-mentioned problems, there are three solutions for improve megaproject existing problems by consulting method, coupon inquiry and data collection method.
2. On the basis of first step (finding solutions), the second step is identified the specific KPIs that need to be measured, in this chapter including the rules and steps for determining KPIs.
3. After finding a solution and establishing KPIs, the thesis need to divide the weights to different KPIs and determine the score formula. so the third step determines its weight and the formula for calculating megaproject performance score.

From these three chapters build a more optimized megaproject performance model, the specific steps are shown in the following roadmap:

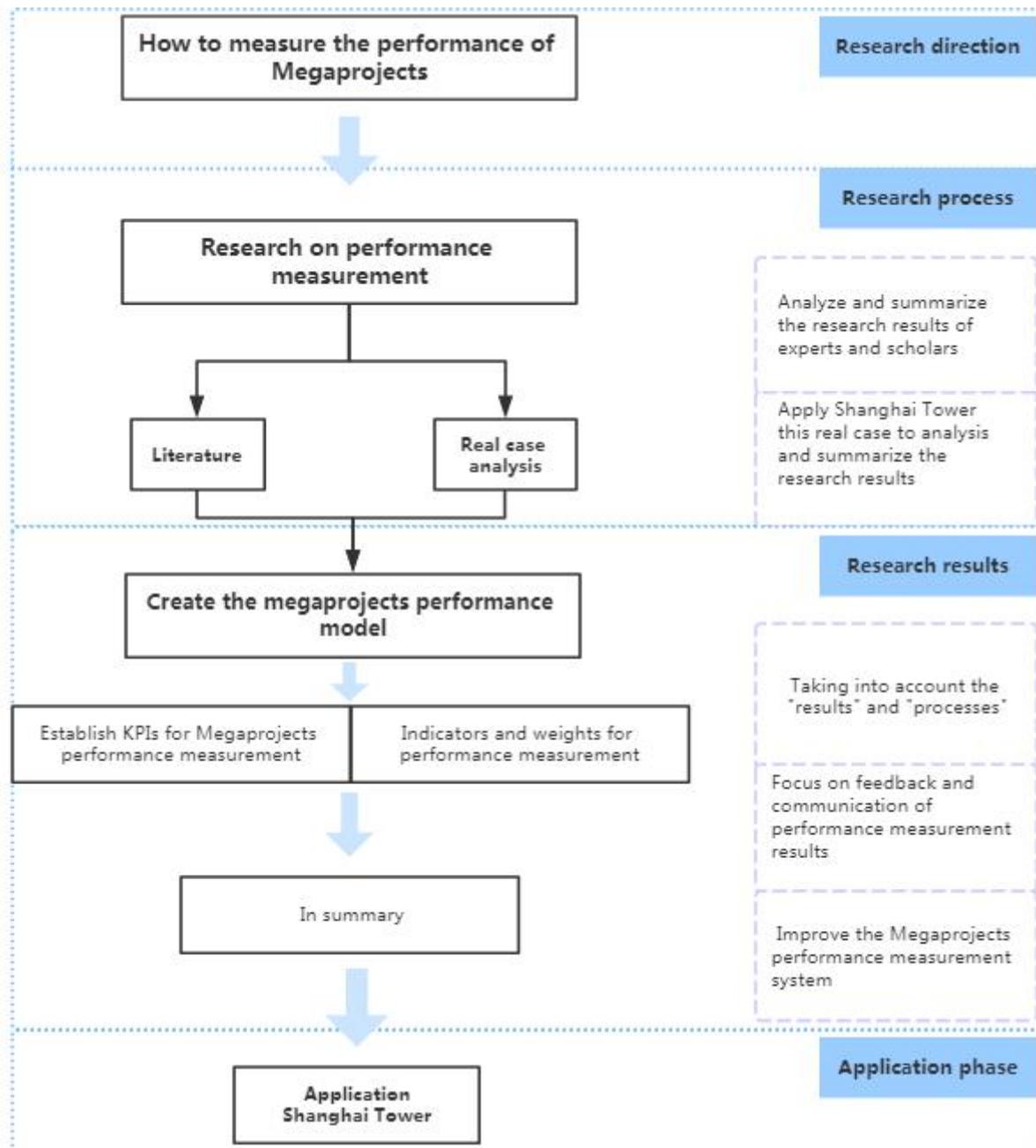


Figure 4.1 Technical roadmap

Source: conclusion from chapter 4

#### 4.2 Improve megaproject performance model

The above analysis and research on megaproject performance measurement is a very important measure for developing performance measurement methods based on stakeholder satisfaction, improving the efficiency of megaproject performance measurement, and optimizing and improving megaproject performance measurement management. This chapter combines the actual needs and operating rules of megaproject and uses the following methods to solve the problems found in megaproject performance measurement management:

#### 4.2.1 Consider both "results" and "processes"

In the case of megaproject, both "performance measurement of engineering project results" and "performance measurement during the project"

In megaproject performance measurement, we tend to focus on the evaluation of performance results, paying less attention to process performance. This is caused by our thinking habits. In the past, we referred to the concept of "performance", which is often seen as a manifestation and result, meaning the result of employee work, while ignoring the procedural meaning of "performance". This kind of "reporting results, light process" performance evaluation method is easy to lead to short-term behavior of employees, too much pursuit of immediate interests, neglecting the details of the construction process, is not conducive to the integration of project resources, and improve the enthusiasm of project staff.

The concept of modern project performance management emphasizes both the process and the results. "Performance" is a concept of integration process and behavior in the perspective of modern management. In particular, in megaproject, due to its long cycle, its construction and operation have strong procedural and phase characteristics. For this reason, megaproject' performance measurement must go through the whole process of project construction. Establish project performance objectives, emphasize the smooth communication between project leaders and project members, establish performance goals in the process of communication and communication, establish key performance indicators, emphasize the behavior of employees in daily work, and identify key tasks in the work process. Performance indicators; improve performance evaluation results, but also in the process of repeated discussions to find ways and means to optimize performance measurement. This is a performance management philosophy that combines processes and outcomes, emphasizing the perfect blend of behavior, processes, and capabilities.

In short, in megaproject' performance measurement, we can't limit performance measurement to a certain link or aspect, and we can't only emphasize the result in performance evaluation. Instead, we should look at megaproject' performance measurement with an open and mobile perspective, and measure performance. Throughout the construction process of the entire project. Only in this way, megaproject' performance measurement can achieve its due effect, and performance measurement management can ensure the normal progress and smooth completion of the project.

#### 4.2.2 Focus on feedback and communication

In the performance measurement of megaproject, managers tend to pay attention to the assessment process, and put a lot of effort into determining the construction plan, performance goals, performance indicators, and objective evaluation of the project staff. However, the results obtained

by performance evaluation often lack effective treatment. Especially after the results of the performance evaluation of the project members, the project members are often not reported to the project, and there is no effective communication between the performance appraisers and the project members. Due to the lack of feedback and communication of performance evaluation results, megaproject' performance measurement is in the form of “performance evaluation, but no performance improvement”, and performance evaluation can not motivate employees to progress.

In fact, around the results of performance measurement, if the assessor, project manager, and project staff can maintain smooth communication and communication, then performance feedback and performance communication will have a very positive effect, which can motivate employees' professionalism and encourage employees. Morale, all members of the project can fully participate in the construction of the project. Therefore, the feedback and communication of performance evaluation results is an important link worthy of attention. In the actual management activities, we must properly handle the relationship between the past and the future, so that performance feedback, performance communication, and performance coaching become the bridge connecting the past and the future.

In order to do a good job of feedback on the performance measurement results of megaproject, the project leader should take the initiative to take responsibility for communication and communication, actively understand the dynamics of employees' thinking, help employees solve problems, and follow up, guide and supervise the results after the performance evaluation results are released. The personnel implemented the rectification, and encouraged the project members to continue their efforts to help employees understand and change the problems existing in the project construction, and do a good job in support service work and performance training. Especially in the face of less than ideal performance results, project leaders should use their guidance, education and training to make employees face the evaluation results. At the same time, the project leader through the post-performance training, so that managers can improve their management level, employees can improve their work ability.

#### 4.2.3 Improve megaproject measurement system

To solve the problems in megaproject' performance measurement, we must start from the system level. Only by further improving and perfecting the performance appraisal system, so that it meets the construction requirements of megaproject, and close to the actual operation of megaproject, can ensure the performance measurement management is implemented. Building a performance measurement system is a strategic issue for enterprise development. At present, in the performance measurement of megaproject, system construction is often neglected. The managers of megaproject

are accustomed to relying on their own experience to conduct performance evaluations and to despise the escort function of the system.

In addition, at present, megaproject' performance measurement model still has many defects. such as, pursuit and focus on short-term evaluation indicators, lack overall comprehensive on the perspective of stakeholder satisfaction, the purpose of performance evaluation always positioning at rewards and salary, and so on, the performance results are connected to the promotion of employees, resulting in short-term psychological and short-sighted behavior of employees. performance model narrowly is not helpful to the incentive effect of performance evaluation, and reduces the positive effect of performance evaluation. the content of many performance appraisal systems does not take into account the needs and feelings of employees. If only the stakeholder satisfaction is emphasized, it is unfair and fair, and it is rejected and criticized by employees.

Therefore, we need to further promote the construction of megaproject' performance measurement model and provide institutional guarantee for megaproject performance management. to improve the performance evaluation model and fully consider the features and reality of megaproject construction and respect the basic laws of megaproject; we must integrate the strategic objectives, management concepts and development plans of the enterprise into the performance evaluation system, so that the performance evaluation system is full of cultural heritage. Adapt to the long-term development needs of enterprises; use long-term vision and overall situation awareness to combine the construction of performance evaluation system with the promotion of core competitiveness of enterprises; it is necessary to have the spirit of reform and innovation that keeps pace with the times, according to the changes of the times and the needs of the realities, timely reform and Improve the performance management system.

#### 4.3 Establish KPIs for megaproject performance measurement

Any company must have a set of standards to measure the effectiveness of its work, which requires the establishment of KPIs. The KPIs managed by megaproject are composed of a series of factors, which are used to measure the performance of employees, the operational efficiency of project execution and the achievement of project objectives, and the practical plan to promote the company's overall vision. KPIs are unique theories in the Balanced Scorecard. No matter how you choose a strategic goal to correspond to a KPI, or the target value and weight setting in a KPI, for most companies, it will be a New topics and challenges.

##### 4.3.1 Principles for establishing key indicators

The KPIs of megaproject must be linked to the development vision and strategy of the entire enterprise. It has the following characteristics: it can be quantified, accessible, easy to understand,

balanced, defined, and linked to action. In the design and planning of the performance management system, it is necessary to train and communicate with all supervisors from top to bottom, clearly identify the KPIs of the employees in the organization department, and feed them back to the decision-makers from the bottom up to make them meet the goals of enterprise development. Match and relate to avoid everyone's behavior, contrary to the operator's goal.

When determining the key metrics for megaproject, follow these guidelines:

First, the construction of the KPI should be linked to the company's goals and strategies. In other words, the KPI comes from the medium and long-term goals of the company and the annual operating plan.

Second, the medium- and long-term goals and annual operating plans are broken down into departmental performance targets (departmental KPIs).

Third, the departmental performance indicators (KPIs) should be broken down into project KPIs.

Finally, the project KPI is broken down into individual KPIs.

In the implementation of megaproject, its key performance indicator is the project. In order to make the project operational, we need to break down the project into individuals, which becomes the top priority for determining megaproject' key performance indicators.

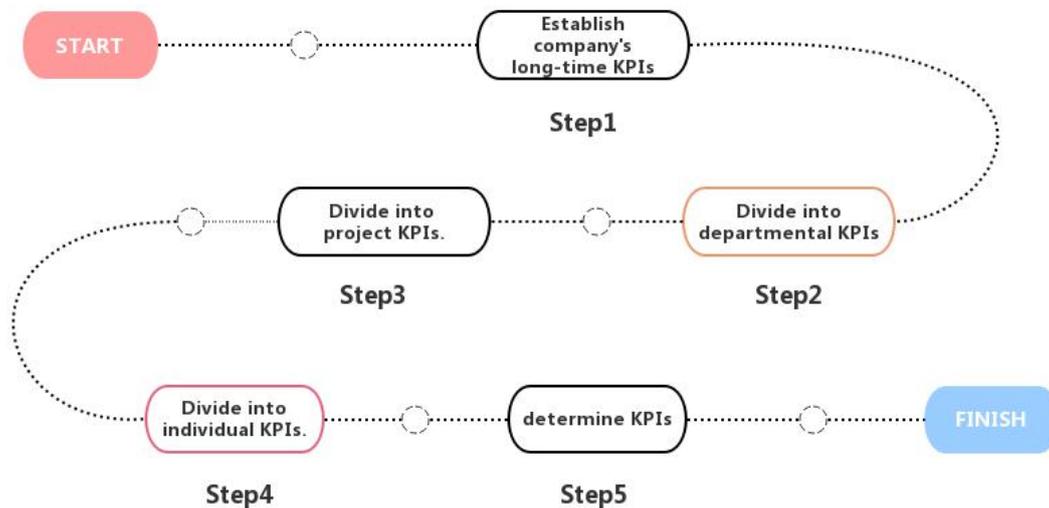


Figure 4.2 Principle of establishment of KPIs

Data resource: conclusion KPIs establishing principle by consulting

#### 4.3.2 Key steps to establish key indicators

The determination of The KPI of megaproject begins with a clear definition of performance.

According to the results of the performance management survey, the KPI indicators and evaluation system are determined through expert interviews and corporate discussions on the existing problems.

First, it is necessary to establish a job responsibility book, job description, and task decomposition;

the leader and the responsible person should negotiate and determine; at the same time, the project manager should fully authorize, the employee's responsibilities should be clear and clear, and operability and achievability. again, KPIs are established according to the SMART principle (S=Specific, M=Measurable, A=Attainable, R=Relevant, T=Time-bound).

On the basis of the above, according to the analytic hierarchy process, the weight of each key indicator is determined. Weights are critical in the process of developing an overall performance evaluation program. The size of the weights indicates the importance of different indicators, and it is important to ensure the rationality and motivation of performance evaluation. The method of determining the weight uses the analytic hierarchy process.

Because megaproject involves many departments and high technical content, and it has a long construction period in the whole project, it is subject to the progress of the main project in terms of overall project progress; in terms of construction conditions, it is subject to the construction environment and regional policies. The construction quality of megaproject largely affects the overall quality and life cycle of the project after its completion. Therefore, in the development of performance evaluation indicators, we must fully consider these characteristics of megaproject, and pay attention to coordinate with other factors.

At the same time, during the operation of the project, pay attention to performance communication, strengthen implementation and improvement, and apply the performance measurement results to the actual work. The key performance appraisal is the basis for the improvement of employees' personal work; it is the basis for the bonus of the project department; it is the reference element for the next project position, company position and salary adjustment; it is also the reference for the company's welfare (holiday and others).

The personnel of the project department shall perform performance appraisal according to the post, and the basis for performance appraisal shall be the job description. The assessment form is designed according to the position and stage. The assessment posts are carried out according to the post design table (as mentioned above, the performance appraisal form is drawn up. The project appraisal stage can be divided into the following three stages: the first stage, the joint design stage; the second stage, the construction stage; the third Stage, delivery acceptance stage, and summarize evaluation at the end of the year and at the end of the project.

## KPIs establishment steps

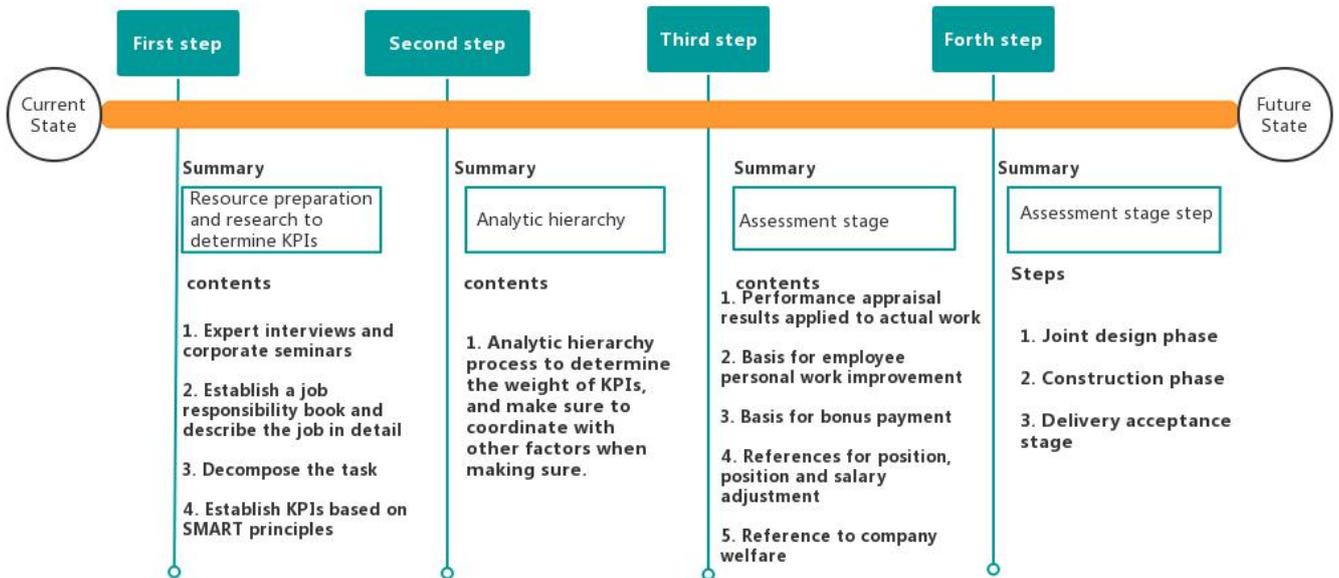


Figure 4.3 KPIs establishment step

Data resource: KPIs establishment steps conclusion by consulting and IPPCE think tank<sup>viii</sup>

### 4.4 Indicators and weights for performance measurement

Establishing performance evaluation standards is the first step in performance management and evaluation. Through job description, task decomposition, discussion and negotiation, performance indicators are established to ensure the objectivity and operability of performance evaluation indicators. Through the performance evaluation indicators, the company's overall vision and engineering project goals are reflected in the actual indicators. On this basis, evaluate the degree of completion of these performance indicators.

#### 4.4.1 Evaluation indicators and weights

Focus on the characteristics and performance measurement in megaproject , this study divides megaproject performance measurement into two parts: “department evaluation” and “personal evaluation”. the weight of departmental evaluation accounts for 60%, and individual evaluation accounts for 40%. in additional the key performance indicators divides into four categories: professional ethics, work attitude, work ability and work performance.

In the meanwhile, the results of each stage evaluation report are respectively included in the annual evaluation report, and then evaluates the average value. according to their different weights summing up the above evaluation indicators (KPIs), the total score of the department and individual evaluation are obtained. finally, the total score plus special contribution of the individual will get the

final performance measurement score. the detail of the performance evaluation form shown in the table 4.2.

Table 4.2 Project performance evaluation indicators and weights (employees)

Performance evaluation of employees			
Departmental evaluation (60%)		Personal evaluation (40%)	
Professional ethics	20	Professional ethics	20
Work attitude	25	Work attitude	25
Work performance	25	Work performance	25
Work ability	30	Work attitude	30
Subtotal		Subtotal	
Special contribution			
Total			

Data resource: some materials provided by experienced megaproject managers in China

Table 4.3 Project performance evaluation indicators and weights (manager)

Performance evaluation of manager			
Departmental evaluation (60%)		Personal evaluation (40%)	
Professional ethics	20	Professional ethics	20
Work attitude	25	Work attitude	25
Work performance	15	Work performance	15
Work ability	40	Work attitude	40
Subtotal		Subtotal	
Special contribution			

Total
-------

Data resource: materials provided by experienced megaproject managers in China

According to the actual construction of megaproject, the performance evaluation of it can be divided into four major indicators: “professional ethics”, “work attitude”, “work ability” and “work performance”. We need to decompose these macro indicators into specific indicators that can be measured, the details are as follows:

First, the indicator of "professional ethics" could be broken down into four specific indicators: self-cultivation, confidentiality awareness, work style, and loyalty.

Second, the “work attitude” indicator can be decomposed into five specific indicators: attendance, teamwork awareness, work enthusiasm, self-motivated, and responsibility.

Third, the “work performance” indicator can be decomposed into five specific indicators: the completion of the annual target, technological innovation in annual, the annual number of solve technical problems, the degree of engineering technology teaching, and the failure rate of engineering technology management.

Fourth, the “work ability” indicator could be decomposed into six specific indicators: professional knowledge, technical experience, technology renewal capability, management coordination ability, judgment and foresight of technical problems, and expansion of other professional capabilities.

The relationship between the evaluation indicators is shown in figure 4.4.

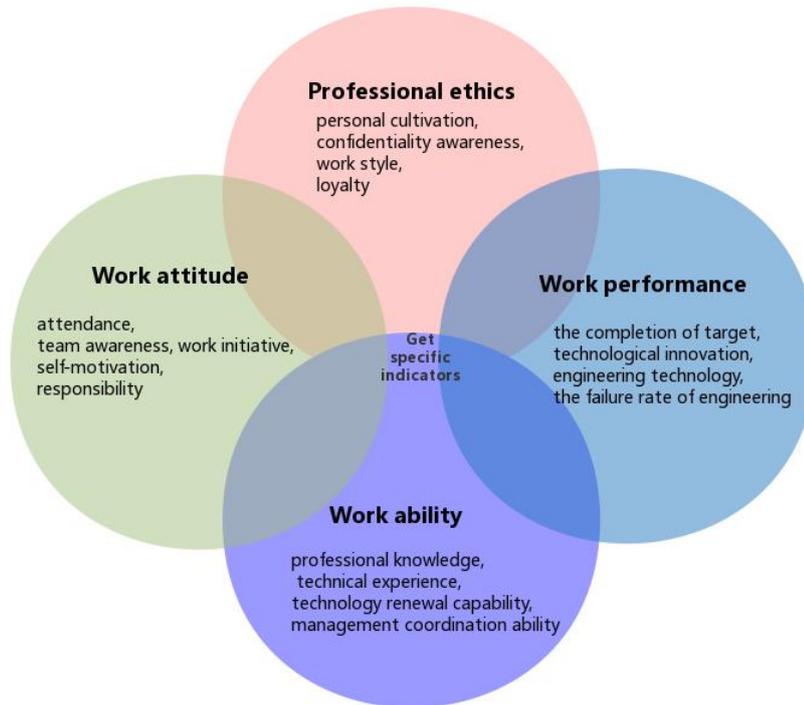


Figure 4.4 Relationship between evaluation indicators

Data resource: conclusion by consulting and material

#### 4.4.2 Weights and scoring formula

(1) Index weight: the weight of performance indicator that is used to measure the importance of this performance indicator in all key indicators. in other words, that mean the key performance indicator the more important, the greater weight of this performance indicator. summing all of the importance weights of each key performance indicator are 100 points.

The basic method for establishing indicator weights is the expert research method. according to the research targets, the thesis interviewed the experts of the megaproject managers and human resources departments, through analysis and conclude, finally identified the different weight of the key performance indicators. details show as follows:

In megaproject performance measurement of project managers, the professional ethics weighted 20%, the work attitude weighted 25%, the work ability weighted 15%, and the work performance weighted 40%. In the performance evaluation of megaproject project members, the professional ethics weighted 20%, the work attitude weighted 25%, the work ability weighted 25%, and the work performance weighted 30%.

(2) Scoring formula: The scoring formula is a statistical formula, after summing up these performance scores, you could get a total value, which is the overall performance of megaproject performance. In order to encourage project members to work harder and achieve better results, the total performance score can exceed 100 points when designing the scoring formula.

In short, it is very important for megaproject to coordinate performance assessments with various factors in terms of overall project progress.

## 5.Application: Shanghai Tower

Focusing on the concept of nature, humanity and the future, the Shanghai Tower strives to create a vertical community, a green community, a smart community and a humanities community with the characteristics of the times. After the project is completed, it will involve various business formats such as office, hotel, conference center, business, and sightseeing.

### 5.1 Project Overview

#### 5.1.1 Background of the Shanghai Tower

Shanghai Tower is located in Lujiazui Financial Center, Pudong New Area, adjacent to Jinmao Tower and World Financial Center. It will become the tallest skyscraper in Shanghai when it is completed. The project consists of super high-rise towers, podiums and basement buildings. The tower building height is 632m and the structural roof height is 580m. It has 5 floors underground and 124 floors above ground. It is an extra-large multi-functional super high-rise building project with a single building area of over 576,000 square meters.

Construction started in 2006, it was basically completed in 2016. The Shanghai Tower is designed by Gensler in the United States. It is designed and constructed by Tongji University. Its facade is composed of double-glazed curtain wall enclosure structure. The flexible design of double-glazed curtain wall enclosure structure can reduce risks and impacts from earthquakes. Natural disasters such as typhoons. The figure 5.1 below shows the shape of the Shanghai Tower.

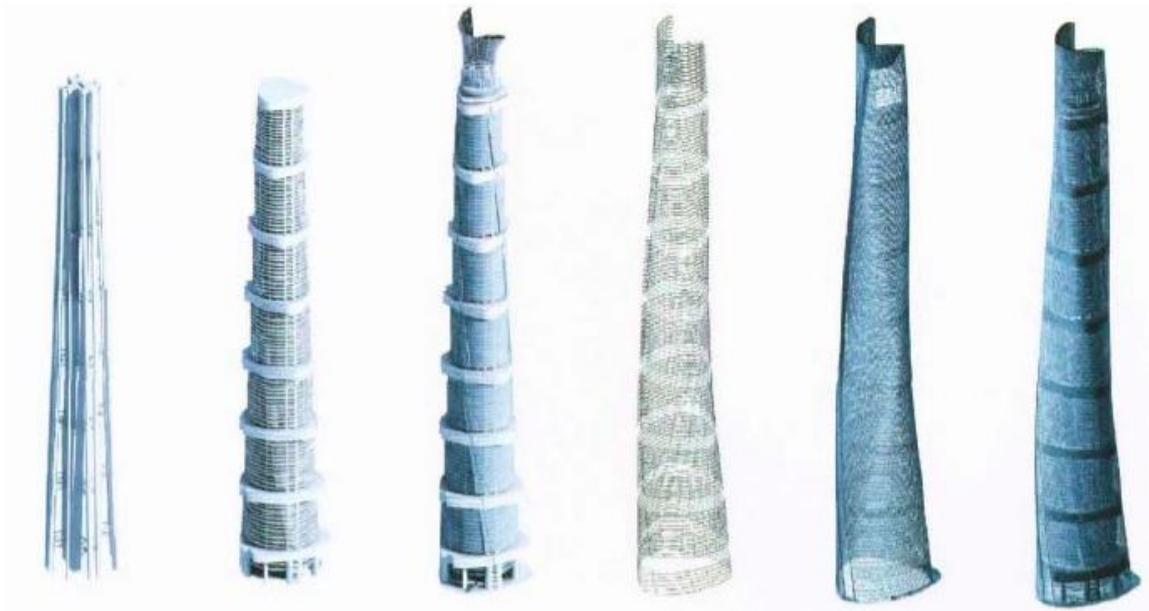


Figure 5.1 The shape of the Shanghai Tower

Data resource:online

#### 5.1.2 Construction unit structure and post setting

Shanghai Tower is contracted by Shanghai Construction Group Corporation, Ltd. The core tube of the building was constructed by Shanghai Construction No.1 (Group) Co., Ltd. Shanghai Construction No.1 (Group) Co., Ltd is one of the participating constructions. In this paper, we focus on the analysis of its various functional coordination and its performance measurement. Shanghai Construction Group Corporation, Ltd. is a large-scale enterprise group supported by the State Council and the Shanghai Municipal Government. It has more than 300 wholly-owned and holding companies, with total assets of 23.8 billion yuan and national owner's equity of 4.8 billion yuan. It has the highest domestic output issued by the Ministry of Construction. Graded building construction and municipal public works contracting double-level qualification; at the same time, it has the import and export management right approved by the Ministry of Commerce and the authority for approval of foreign affairs authorized by the Ministry of Foreign Affairs; the group has formed main business in construction and installation , industry, real estate and investment. Its organizational structure is shown in the figure 5.2.



# SHANGHAI CONSTRUCTION GROUP CO., LTD.

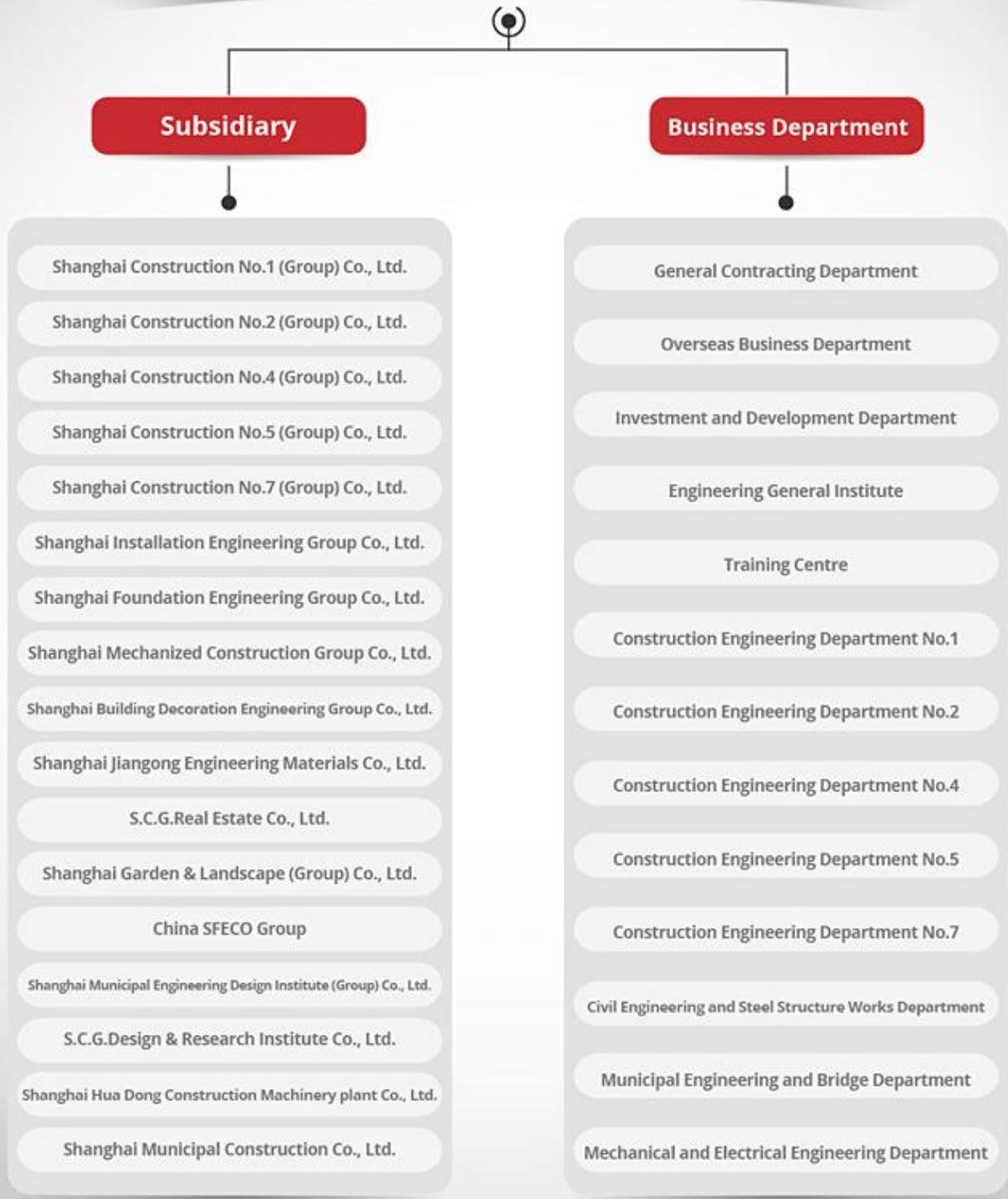


Figure 5.2 Shanghai Construction Group Corporation, Ltd. organizational structure

Data resource: Shanghai Construction Group Corporation, Ltd. official website

In the completed project, the project quality pass rate and excellent engineering rate are above, and has been rewarded and commended by the relevant state ministries, provincial and municipal levels. In recent years, the company has gradually strengthened various aspects of reform, and has basically established a series of systems such as project operation control and project accounting, and has shown its good effect on project implementation. However, in the assessment of project personnel, it is still necessary to continue to establish a more complete evaluation system to achieve better goals.

In order to smoothly carry out the Shanghai Tower, in accordance with the company's project management regulations and internationally accepted project management methods, the company set up the engineering project department, determined the overall objectives of the project, and thus determined the performance management objectives.

**Project Department and Position** The main body of Shanghai Center Building is constructed by Shanghai Construction No.1 (Group) Co., Ltd., a subsidiary of Shanghai Construction Engineering Group. The organization of its subsidiaries is shown in Figure 5.3. Daily organization and management work to promote the smooth development of the project.

Shanghai Construction No.1 (Group) Co., Ltd. organizational structure

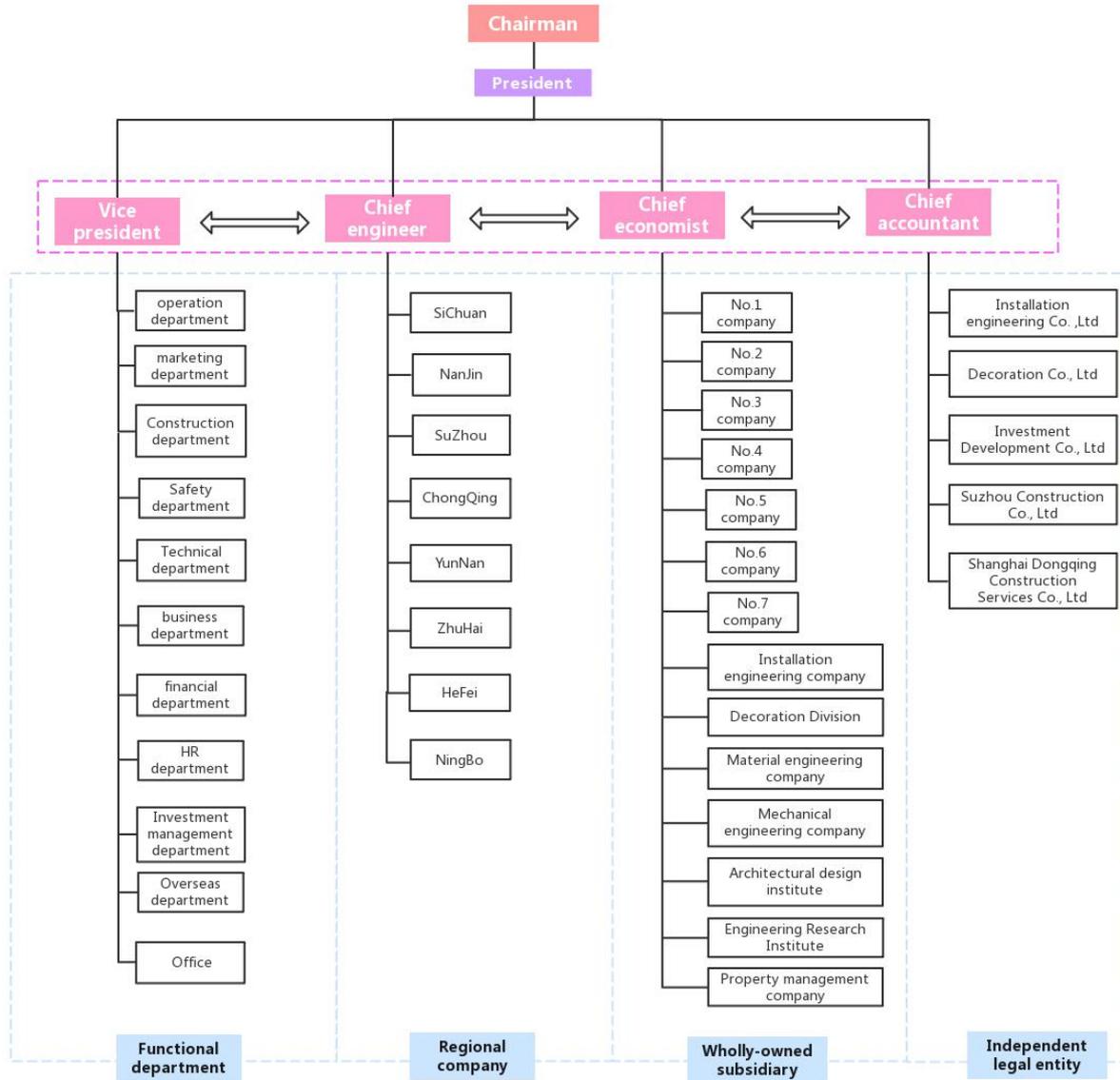


Figure 5.3 Shanghai Construction No.1 (Group) Co., Ltd. organizational structure

Data resource: Shanghai Construction No.1 (Group) Co., Ltd. official website

The unified coordination and management of the project construction is coordinated by the vice president, chief engineer, chief economist and chief accountant. Its duties include: overall project development, project implementation procedures, project financial measurement, and formulation of engineering construction, procurement and insurance policies, review and determine major programs in the project implementation process, lead coordination and processing of engineering projects and other professional departments of the company. , the local government authorities, and the relationship between tax, banking, insurance, supervision and other units. In order to effectively

manage the project, the project manager department uses the matrix management model, including: engineering technology department, procurement contract department, material management department, measurement and finance department, office, each sub-department involves daily administration, engineering technology, procurement contracts, Material management, measurement and financial responsibilities.

## 5.2 Apply performance model to analysis

Due to the huge project of Shanghai Central Tower, the project branch system is complex, and there are many projects participating in the project. All aspects of the project construction, various links, and various owners' rights and interests are interrelated, and involve the coordination and contract management of personnel and projects. The control of investment, cost, schedule and other KPIs poses a great challenge to the overall coordination and effective management of the project.

The project is expected to have a total investment of about 1.85 billion euros. The huge construction cost requires more accurate performance models and management tools to guarantee.

A variety of factors make it more important to build an efficient performance model.

Next we apply the model to measure the Shanghai Tower performance:

### 5.2.1 Determine the target of the performance measurement

The objectives of performance measurement management are: to complete the various indicators issued by the group; to achieve the project construction according to the completion of the contract and quality of the completion of the contract; meet stakeholder satisfaction to establish a good customer relationship and further expand market share. Establish personnel assessment goals, and expected goals, according to the score results, the employees are divided into four levels: excellent, good, meet the standards, and urgently need improvement.

For company leaders, project members, and the company as a whole, the objectives of the Shanghai Center Building project performance measurement are different, and the performance objectives of each entity are as shown:



Figure 5.4 Project performance measurement target for different objective

Data resource: conclusion from consulting experienced project managers

### 5.2.2 Establishment of performance measurement system

The responsible persons of the Shanghai Center Building have clearly defined their duties and are now working on the job description. Establish a set of performance appraisal system, the human resources department is responsible for formulating relevant appraisal forms, and organize the project department personnel and relevant appraisers to fill out.

Regarding the content of the assessment, it mainly consists of two parts: The assessment is based on the department in which the employee is located, and is carried out in conjunction with the completion of the project objectives. the assessment results are linked to the year-end rewards and benefits. According to the score, the company's human resources department sorts the assessment results and extracts a certain percentage of employees as the target of reward, promotion and key training.

Regarding the evaluation process, according to the actual situation of the Shanghai Tower, the project performance evaluation is carried out in a joint evaluation stage, construction, and acceptance and delivery stage, and a summary evaluation is carried out at the end of the year and at the end of the project. The specific process show as figure 5.5, 5.6 in table 5.1:

The first stage is for employees to fill out and self-evaluation stage. and then the direct evaluation stage. next is the evaluation and summary stage of the department manager. follow stage is the interview phase. The last is the summary phase of the Human Resources Department.

In the evaluation process, the supervisor can make appropriate adjustments to the score of the person being evaluated, but the reasons must be indicated.

Regarding the evaluation criteria and requirements, 20 KPIs are decomposed into quantifiable indicators, and each index has a score of 5 points. The specific scores show in table 5.1.

When determining the score, the project manager follows the following distribution ratio, show in table 5.1.

The average score of individual performance indicators for all personnel in the department must not exceed 80, but not 80 points per person. Employees with a performance of 90 or above must be discussed and approved by the company's Human Resources Department.

The above operational mechanism is realized by two parts, and the evaluation criteria are finally obtained. The specific cooperation process is shown in the figure 4.7.

Through the conclusion, the performance measurement system is summarized as Table 5.1.

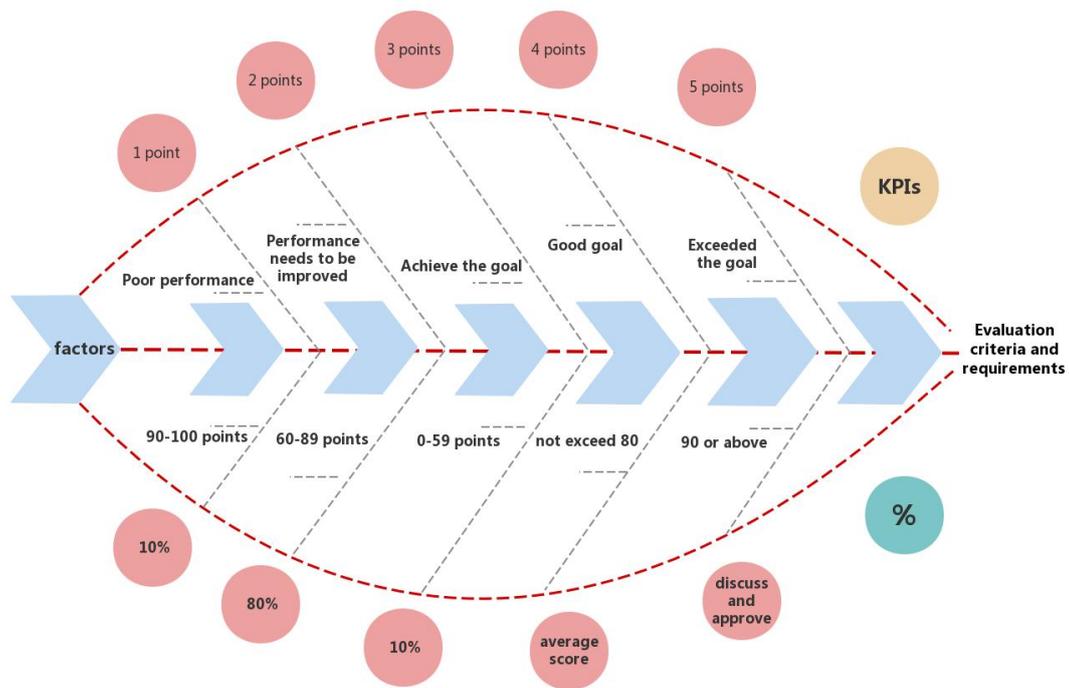


Figure 5.7 Cooperation process of score and distribution ratio

Data resource: conclusion from experienced project managers provided material

Table 5.1 Performance measurement system conclusion

Performance measurement system		
Evaluation Contents	Evaluation Process	Evaluation criteria and requirements
<p>This assessment is based on the department in which the employee is located, and is carried out in connect with the completion of the project objectives.</p>	<div style="text-align: center;"> <pre> graph TD     A[Project manager self-assessment] --&gt; B[Project manager]     subgraph C [ ]         C1[chief accountant]         C2[chief economist]         C3[Chief engineer]     end     C --&gt; B     D[Department manager] --&gt; B     E[Colleague] --&gt; B             </pre> <p>Figure 5.5 Project manager job performance evaluation process</p> <div style="text-align: center;"> <pre> graph TD     A[Employee self-assessment] --&gt; B[Employee]     C[Project manager] --&gt; B     D[Department manager] --&gt; B     E[Colleague] --&gt; B             </pre> <p>Figure 5.6 Employee performance evaluation process</p> </div> </div>	<p>Scores:</p> <p>Poor performance: 1 point</p> <p>Performance needs to be improved: 2 points</p> <p>Achieve the goal: 3 points;</p> <p>Good goal: 4 points</p> <p>Exceeded the goal: 5 points.</p> <p>Distribution ratio</p> <p>90-100 points accounted for 10%;</p> <p>60-89 points accounted for 80%;</p> <p>0-59 points accounted for 10% ;</p>

Data resource: draw a table from thesis results

According to the above principles, the project manager (evaluator) comprehensively compares and weighs the performance completion of all personnel within the department, and then draws the final individual performance indicator and completes the employee performance evaluation form.

The last part, performance interview, is used for employee performance analysis and performance improvement. The performance improvement measures will be used as an important basis for the development of the next year's employee training program. The Human Resources Department will provide employees with a summary of the training courses, and employees will communicate with their immediate supervisors and confirm the training courses. see the appendix for the performance interview form.

### 5.3 Summary

Through theoretical analysis and the successful experience of existing projects, combined with the existing performance measurement mode of the unit, the improvement strategy of performance management is proposed, and then a set of evaluation system and evaluation indicators are established to be applied to the implementation process of megaproject. In this process, it should be noted that the establishment of performance appraisal indicators cannot be based solely on theoretical analysis or copying the existing experience. In the application process, it needs to be adjusted according to the characteristics of specific projects, personnel composition and project stakeholder satisfaction. In addition, in order to be more realistic, performance management plays a more important role.

Through the implementation of the above-mentioned series of performance measurement measures, the performance measurement of the whole process was realized during the whole project implementation process. Through the formulation of the performance appraisal method, the employees clearly defined the work focus and work direction, correctly handle the benefit of enterprises, projects and individuals in the work process; through the results of performance appraisal, employees are identified the advantages and disadvantages of their work. It also provides a basis for the company to determine the salary, promotion, training, etc. of employees; Through performance interviews, performance management has become a benign interactive process, and performance management, clarity and performance improvement of performance management have achieved good results.

In this method, both megaproject' comprehensive monitoring and stakeholder satisfaction are realized, which effectively enhances the efficiency of performance measurement, and plays an active role in the performance measurement management of megaproject.

## 6.Explain results and look for future

### 6.1 Takeaway

The thesis analyzing the megaproject's questionnaire results, consulting the professionals who can be touched within personal ability, do some literature analysis and some methodology explained illustrated. to developing a more optimized performance model for megaproject, and then applying the improved model into Shanghai Tower in China. through analysis and conclusion, derived some conclusions and made some contributions that can be applied to improve performance of megaproject.

The thesis found that there are mainly existing three aspects problems cause poor megaproject performance measurement in construction phase:

Firstly, performance measurement and performance assessment confusion;

The second point, megaproject performance measurement is bureaucratic, formalized, done for appearance's sake, but without practical effect. and sometimes measurement ways are too simple, lack of feedback and communication.

The last point is that lack effective incentive mechanism.

After identifying the main problems, there is a directly understanding of the problems, and then it is need to build a more optimized model to solve these three problems, there are three steps:

1. In response to the above-mentioned megaproject performance problems,in megaproject construction phase, there are provided some actionable suggestions. take into account both "results" and "processes". secondly, pay more attention to feedback and communication. meanwhile, improve megaproject measurement system. during specific operations, the following measures can be taken, such as: replace "supervisor-centric" with "two-way communication" performance evaluation; further clarify KPIs standards; strengthen awareness of supervisor and employee performance measurement systems, etc.
2. On the basis of first step (finding solutions), the second step is identified the specific KPIs that need to be measured, in this chapter including the rules and steps for determining KPIs. determine the specific KPIs can help the megaproject performance measurement model to be more accurate and efficient.
3. After finding a solution and establishing KPIs, the thesis need to divide the weights to different KPIs and determine the score formula. so the third step determines its weight and the formula for calculating megaproject performance score.

According to this megaproject performance measurement model applied to Shanghai Tower, it has a very good effect, in this case, it is established a very clear KPIs system to help project managers to measure performance problems in actual work, which makes fundamentally improved in megaproject poor performance measurement.

Therefore, this shows that it is very useful and necessary to conduct targeted research on megaproject's performance measurement, and then to set up a performance measurement model. this megaproject performance measurement model not only can apply in solving megaproject performance problems, but also can improve enterprises competitive advantage and bargaining power, in other words it is can increase stakeholders benefit realization and stakeholders satisfaction. in the meanwhile, it also will generate a win-win situation, it also generate great significant to fast development of industries.

## 6.2 Looking for future

The construction phase of megaproject is a very complicated problem, and it is full of various uncertain factors. therefore, in the construction process, how to effectively carry out performance measurement that always is a difficult research point. it is connect with enterprises management ability and decision-making ability. since in this thesis that makes a detailed analysis of the case of Shanghai Tower, and proposes three solutions for existing problems. hoping it is can improve the megaproject performance measurement model, this thesis has certain reference significance.

However, the performance of megaproject measurement is always a complex system engineering, and there are still many problems need to be solved. for example, there are many disadvantage in the improvement of the evaluation process, the positioning of performance goals, the improvement of evaluation methods, and so on. in particular, how to take into account stakeholder satisfaction in performance measurement, connect enterprises benefits, and employee satisfaction, combine the improvement of individual performance of employees with the core competitiveness of the enterprise, and achieve a all-win situation for owners, constructors, supervisors, and project members , in the future, it needs further research.

## Appendix

Performance Appraisal Form (employees)							
<b>Department:</b>		<b>Name:</b>		<b>Position title:</b>		<b>Date:</b>	
Type	Weight	KPIs	Weight	Self-evaluation	Executive Evaluation	Score	Remark
<b>Ability</b>	<b>30</b>	Technical experience	5				
		Technological innovation	5				
		Coordination	5				
		Ability to predict technical difficulties	5				
		Expand other professional capabilities	5				
		Profession knowledge	5				
<b>Attitude</b>	<b>25</b>	Attendance	5				
		Teamwork	5				
		Work initiative	5				
		Sense of responsibility	5				
		Motivated	5				
<b>Performance</b>	<b>25</b>	Goal completion	5				
		Gain technological innovation	5				
		Solving technical problems	5				
		Degree of technology inheritance	5				
		Technical management error rate	5				
<b>Professional ethics</b>	<b>20</b>	Personal cultivation	5				
		Confidentiality	5				
		loyalty	5				
		Patience	5				
<b>Total</b>	<b>100</b>						
<p><b>Through the above assessment, the overall score is:</b></p>							
<p><b>The supervisor's evaluation of the appraiser:</b></p> <p><b>advantage:</b></p> <p><b>Disadvantages:</b></p>							
						<b>Supervisor signature:</b>	
						<b>Date:</b>	

**Performance evaluation Form (mangers)**

**Department:** \_\_\_\_\_ **Name:** \_\_\_\_\_ **Position title:** \_\_\_\_\_ **Date:** \_\_\_\_\_

Type	Weight	KPIs	Weight	Self-evaluation	Executive Evaluation	Score	Remark
Ability	40	Technical experience	5				
		Technological innovation	5				
		Coordination	5				
		Ability to predict technical difficulties	5				
		Expand other professional capabilities	5				
		Profession knowledge	5				
Attitude	25	Attendance	5				
		Teamwork	5				
		Work initiative	5				
		Sense of responsibility	5				
		Motivated	5				
Performance	15	Goal completion	5				
		Gain technological innovation	5				
		Solving technical problems	5				
		Degree of technology inheritance	5				
		Technical management error rate	5				
Professional ethics	20	Personal cultivation	5				
		Confidentiality	5				
		loyalty	5				
		Patience	5				
<b>Total</b>	<b>100</b>						

**Through the above assessment, the overall score is:**

**The supervisor's evaluation of the appraiser:**

**advantage:**

**Disadvantages:**

**Supervisor signature:**

**Date:**

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