

Study on a Maturity Model of Project Management Capability for a Large Aircraft Main Manufacturer

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Abstract: This paper is to study a maturity model of project management capability for a large aircraft main manufacturer using a capability maturity model and an organizational project management maturity model. First , we build the project management capability maturity level , its features , key process areas and best practices to provide a clear goal and path for the development of project management capability. Secondly , we set a project management capability evaluation index system according to the project management processes and key process areas. Moreover , we use the fuzzy mathematical theory to evaluate the project management capability maturity level. Finally , the large aircraft main manufacturer can choose the best practices based on the evaluation of the maturity level so as to reach the purpose of improving project management capability of the main manufacturer gradually.

Key words: large aircraft main manufacturer; maturity model; project management capability; maturity level

1 Introduction

Research and development of large aircraft is one of the important stratagems made by our government for building innovative country , improving independent innovation capacity and enhancing core competitiveness^[1]. Development of large aircraft , will drive fluid mechanics , solid mechanics , computational mathematics , thermal physics , chemistry , information science , environmental science , and many basic science disciplines^[2]. Since the end of the twentieth century , in the increasingly fierce competition in the aviation market , some of the world's top level aircraft manufacturers continue to sell production units , or even no longer retain this ability , producing most of the body is no longer the console manufacturer's work , but by a group of suppliers , airframe manufacturing into similar airborne equipment procurement supporting mode.

This new model is called " the main manufacturer-supplier" mode^[3]. This new management mode , with its low cost , high innovation , fast-listed features , adopted by more and more manufacturers also attracted the attention of scholars^[3-5].

Under this mode a large aircraft main manufacturer is mainly responsible for the overall project management , the comprehensive coordination and integration of aircraft assembly. Therefore , the ability of project management has become the "first" competence of a core competence system of the large aircraft main manufacturer; how to improve ability of project management is the most important issue placed in front of the large aircraft main manufacturer. The maturity model provides a way of thinking for us to solve this problem; it is based on continuous improvement , improved perspectives and ideas; and it takes ability as a continuous improvement process , dividing the abili-

ty into different levels , along with the development of practice and improve. In view of this , this paper will establish a new project management capability maturity model of a large aircraft manufacturer based on different maturity levels to choose different best practice to improve the capacity of project management.

2 Capability maturity model

Capability Maturity Model(CMM) , proposed by the Carnegie Mellon Software Engineering Institute (SEI) in 1987 , is a method used for software development process , software development capability assessment and improvement^[6]. Since then , according to the needs of market development , beginning in August 2000 , SEI launched the Capability Maturity Model Integration (CMMI) . CMMI is a process of improving the quality and efficiency of software development management systems , combining the core ideas of 6Sigma , TQM , ISO9000 and other standards systems. The model for the project management process divided management ability of software development projects into five levels , namely: the initial level , the definition level , repeatable level , management level and optimization level. The purpose of this model is to help project organization properly assessing the current level of project management and detect problems in the management process promptly in order to achieve a higher level and to determine the level of key processes which require institutionalization. Maturity assessment can encourage project organization to continuously improve their project management level.

In recent years , various organizations and scholars presented their project management maturity models , on the basis of the CMM. Which are the most representative models from the PMI Project Management Institute. They presented the OPM3 maturity model in 2003 (Organizational Project Management Maturity

Model) ; the project management maturity is defined as the four levels (standardized , measurable , controllable , continuous improvement) , nine knowledge areas and five management processes; And considering not only the relationship between maturity and nine knowledge areas of project management , but also considering the relationship between the maturity and the five management processes of project management ^[7] .

Its basic elements include: best practices (mature ways proved by practice and widely accepted) , ability composition , path , visible results , etc. Now there are more than 30 varieties in a common maturity model. Conceptually , most of those are developed from the SEI capability maturity model. Today it has become the software industry's most authoritative assessment certification system. CMM and OPM3 thinklifting capacity is not easy and it is a progressive , gradual upgrade process. It has the ability to develop into several maturity levels , except for the first level , the rest of each level defines several key process areas required to achieve this level (Key Process Areas , KPA) , each KPA containing a series of targets , only achieving these goals the ability will step on a new level of development. Targets for key process areas are achieved by some of the best practices (Best Practices , BP) of an enterprise operating level. Ability level and the characteristics of each KPA and BP are not the same , according to the business situation to identify the level of the ability , and follow key process areas and best practices to operate and gradually improve business capabilities.

3 The level of project management capability maturity

The project management capability maturity model is a tool to identify the enterprise project management capability used to measure the degree of certainty of

implementing the project target of the organization. In the meantime it also has a diagnosis function to make sure the advantages and problems of enterprise project management and improvement order of enterprise project management capability.

Maturity level division needs to follow certain principles. Using CMM and OPM3 for reference , it is a key to judge the maturity of capacity of an organization that includes controllability of the management and development process. It represents the standardization of a process and the predictability of result. So the

controllability could be seen as the key standard to divide the project management capability. Project management capability maturity level is developed step by step. Each level has a different characteristic. Based on the development process of project management capability and the thought of coordinated development of the core abilities , the project management capability maturity level is divided into five levels: initial level , growth level , management level , optimization level and coordination level. Each level characteristic is shown as Figure 1.

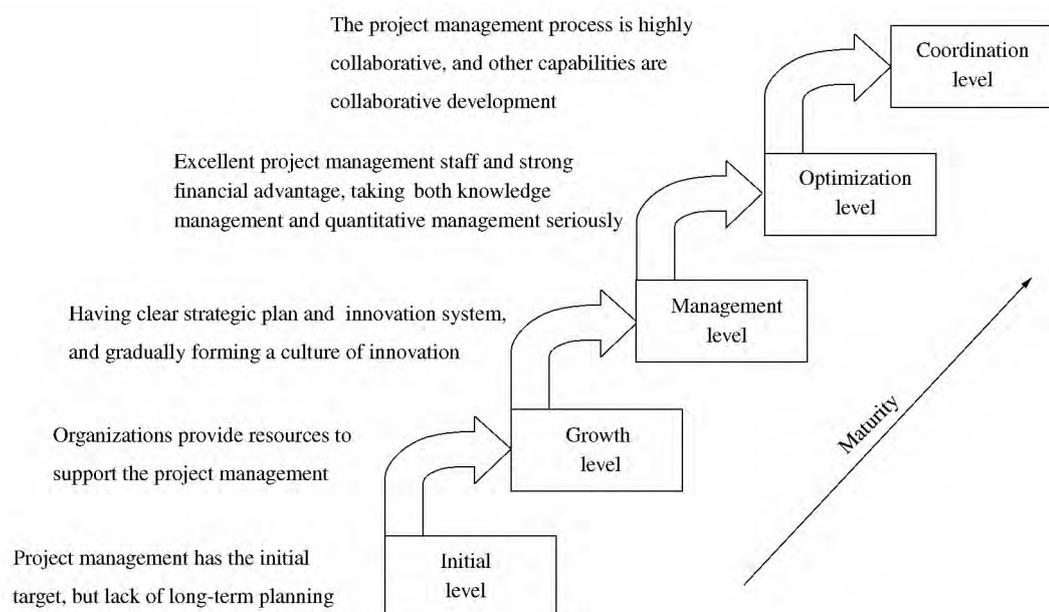


Figure 1 The level and characteristics of project management capability maturity

4 KPA and BP of project management capability maturity level

Except for describing the characteristics of levels , the project management capability maturity level also needs to build the corresponding KPA and BP according to the maturity level. KPA is to see the level characteristics as targets. BP is the specific practice under the guidance of each KPA target. It would achieve the corresponding maturity level requirements through the implementation of BP to carry out KPA targets. When

it achieved all KPA of a certain level , the enterprise maturity would be developed to the next level. At this time , it needs to reposition the new KPA and BP. It would achieve the new level requirements through the implementation of new BP to carry out new KPA targets. Such cycle , makes enterprise project management capability maturity level developing from low to high , till the enterprise project management overall capability would be enhanced. The KPA and BP of project management capability level are shown in Table 1.

Table 1 The KPA and BP of the level of project management capability maturity

The level of project management capability maturity	KPA	BP
Initial level	Pay attention to project management Standardize project management process	Culture system consciousness , propaganda successful project management concept , provide resources to support the project management
Growth level	Introduction of project management professional Develop an appropriate project Management organization structure	Investment in fixed project funds , introduction of project management personnel and professional equipment , develop appropriate project management organizational structure
Management level	Prediction and evaluation of project management Information management	Develop long-term project management strategy , organize experts to predict and evaluate project management ability , information management , accelerate the speed of information exchange
Optimization level	Knowledge management Quantitative management	Establish knowledge management system , form a learning organization
Coordination level	Multi project management is collaborative	The project management process is collaborative , maintain the development of coordination with other core competence

5 The evaluation index system of project management capability maturity

Project management capability is a kind of comprehensive ability based on an innovation process. It needs to follow the principles of comprehensiveness , objectiveness and measurability. Level 1 evaluation index selected five indicators: project investment , project implementation , project output , project management and project coordination. The secondary in-

dex was composed of a personnel indicator and measurable key indicators. Each indicator element reflected a different project innovation. The evaluation index system revolves around the KPA of maturity level. But it is not completely corresponded to the KPA system due to the principles of comprehensiveness , objectiveness and measurability. It takes evaluating enterprise project management capability maturity comprehensively as the starting point.

Project investment capability mainly evaluates the input intensity of a project. In a certain range, project capability is positively correlated with project investment level. It is a key indicator to evaluate project management capability. This indicator selected personnel elements to include project personnel investment intensity, project personnel per capita project fund, and funds indicator. These three indicators evaluated enterprise project innovation investment intensity from the two aspects of personnel and funds.

Project implementation capability is the basic condition to assess whether an enterprise has project innovation. It includes personnel and equipment conditions. The more skilled personnel and advanced equipment, the project designed products would be the more around with the innovation concept, and the more suitable for the market. The personnel indicator is the ratio of technical personnel. Equipment indicator elements include the rate of fixed assets and equipment and the coefficients of new equipment. Furthermore, it is necessary to evaluate the project implementation capability through the efficiency of production.

Project output capability evaluates an enterprise project level from the angle of innovation product. It is the most compelling indicator to evaluate project capability and enterprise innovation capability. This indicator includes per capita development product, the quantity of patent and independency project product. Among them, the improvement of project output capability requires strong innovation capability and abundant innovation resources which are important indicators to evaluate enterprise innovation capability.

Project management capability mainly performs in support of a management layer for project design. It

includes strategic positioning, frequency of innovation, innovation incentive mechanisms and industry-university-research cooperation ability. Strategic positioning is to improve innovation to enterprise strategy height. It considers which key areas should be innovated, what innovational methods should be chosen and whether the enterprise has enough material and human resources for innovation. Evaluation of strategic positioning is marked by the enterprise leaders according to the importance for strategy, which is a subject indicator. Frequency of innovation is a record of the quantity of innovation in each year. It is a quantitative indicator to evaluate the innovation results under the guidance of strategic positioning. It could objectively describe the enterprise project management capability and innovation efficiency. Innovation incentive mechanism evaluates enterprise project management capability from the angle of the project personnel's wage level. It is the most direct way to drive the staff to innovate. Industry-university-research cooperation ability evaluates the leaders' cooperation management ability according to the quantity of industry-university-research cooperation results.

Project coordination capability is an ability to help each other with a common target in different departments. It needs effective communication and a rapid information channel. Good coordination degree shows collecting and deriving information and knowledge from project experience. It uses information and knowledge to increase the value for an organization. It makes the whole enterprise possess a highly prosperous innovation culture which is similar to the learning organization culture. It also makes the innovation process coordinated and helps to adjust the internal and adapt in external environment. The specific calculation method of each indicator is shown in Table 2.

Table 2 The evaluation system of project management capability maturity

The first level index	The second level index	Calculation method
Project investment capability x_1	Project funding intensity x_{11}	Project funding/total core funding for capacity building
	Project staff input intensity x_{12}	Total project personnel/total number of employees
	Project personnel per capita funding x_{13}	Project funding/project personnel
Project implementation capability x_2	Engineering and technical personnel ratio x_{21}	Number of engineering and technical personnel/total number of employees
	The rate of fixed asset equipment x_{22}	Total fixed assets/total number of employees
	The new degree coefficient of equipment x_{23}	Equipment , net assets/equipment assets at cost
Project output capability x_3	The rate of research results into production x_{24}	Total number has been applied and the results achieved/outcomes
	Project personnel per capita developments x_{31}	Identification number of achievements/number of project personnel
	Number of patents x_{32}	The number of patents and proprietary technology ownership
Project management capability x_4	The rate of self project results x_{33}	The number of independent project outcomes/number of the entire project
	Strategic position x_{41}	Strategic targets completed/all strategic targets
	The frequency of innovation results x_{42}	The number of annual innovation achievements
	Innovation incentive mechanism x_{43}	Project personnel per capita annual income/corporate average annual per capita income
Project coordination capability x_5	Cooperative capacity x_{44}	Cooperative outcomes/results of the entire project
	The degree of internal project collaboration x_{51}	Completed schedule/total schedule
	The degree of external project collaboration x_{52}	Difference between project management capacity level and other core ability level

6 Project management capability maturity evaluation

The main evaluation methods for capability maturity have scoring method, analytic hierarchy process, fuzzy comprehensive evaluation method, data envelopment analysis, network evaluation method, multi-level gray evaluation and close value method. As the project management capability maturity level evaluation factors will inevitably somewhat vague, it is difficult to use precise mathematical methods to solve; this article uses the fuzzy comprehensive evaluation theory to evaluate.

The basic idea of the fuzzy comprehensive evaluation theory is using the linear transformation principle and maximum membership degree principle, considering various factors related to the things being evaluated, then making a reasonable evaluation^[8]. First, establish an evaluation index system and index elements; secondly, calculate the index weight; and finally, use fuzzy mathematics to calculate the level of project management capability.

1) Determining the index factor set

From Table 2 we can set X is a project management capacity factor composed of five first level indexes, $X = (x_1, x_2, x_3, x_4, x_5)$; x_i representing any one of the x_1 to x_5 , is the essential factor level, which consists

of the corresponding second level index, $x_1 = (x_{11}, x_{12}, x_{13})$, $x_2 = (x_{21}, x_{22}, x_{23}, x_{24})$, $x_3 = (x_{31}, x_{32}, x_{33})$, $x_4 = (x_{41}, x_{42}, x_{43}, x_{44})$, $x_5 = (x_{51}, x_{52})$.

2) Calculating the index weight

To facilitate the calculation and collection of data, the Delphi method can be used to calculate the index weight, normalizing indicators and getting index weight set, respectively indicating management capability index weight: $A = (a_1, a_2, a_3, a_4, a_5)$, Every index weight is: $a_1 = (a_{11}, a_{12}, a_{13})$, $a_2 = (a_{21}, a_{22}, a_{23}, a_{24})$, $a_3 = (a_{31}, a_{32}, a_{33})$, $a_4 = (a_{41}, a_{42}, a_{43}, a_{44})$, $a_5 = (a_{51}, a_{52})$.

3) Determining the evaluation set

The evaluation set is a set of evaluation of project management competence level; in the project management capability maturity model, evaluation set is the five maturity levels: initial level, growth level, management level, optimization level and coordination level. From low to high, corresponding to the evaluation set, $V = (v_1, v_2, v_3, v_4, v_5)^T$. The evaluation set has a certain range for each grade and embodies the value interval.

And each level requires a certain fraction composition evaluation score level; generally take the median of the score interval as shown in Table 3.

Table 3 Evaluation set score interval and grade scores

The level of project management capability maturity	Dividing the score interval	Level score
Initial level	0~49	25
Growth level	50~69	60
Management level	70~79	75
Optimization level	80~89	85
Coordination level	90~100	95

So get the evaluation set $V = (v_1, v_2, v_3, v_4, v_5)^T = (25, 60, 75, 85, 95)^T$.

4) Determining the fuzzy evaluation matrix

(1) Establish fuzzy evaluation matrix R_i of each indicator element from x_i to V , indicating x_{ij} ($x_{ij} \in x_i$) the membership grade of v_j ; specifically, r_{ij} represents the i element x_i on j comment v_j frequency distribution, be

normalized so that $\sum_{j=1}^5 r_{ij} = 1$, get the second index fuzzy evaluation matrix:

$$R_i = \begin{bmatrix} r_{i1} & r_{i2} & \cdots & r_{i5} \\ r_{21} & r_{22} & \cdots & r_{25} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{n5} \end{bmatrix} \quad (1 \leq n \leq 5)$$

Because the number of the evaluation level V is determined to be five, so that the matrix list is five, and the number of rows in the matrix contained is determined by the number of elements x_i ; if R_1 is a matrix of three rows and five list, R_5 is a matrix of two rows and five list.

(2) Take each index weight and its corresponding fuzzy evaluation matrix to use matrix synthesis operations, and normalize to give each single factor evaluation results:

$$B_i = A_i \circ R_i = (b_{i1}, b_{i2}, \cdots, b_{i5}) \quad (1 \leq i \leq 5)$$

Project management capability fuzzy evaluation matrix

R includes five index evaluation results, namely:

$$R = \begin{bmatrix} B_1 \\ B_2 \\ \cdots \\ B_5 \end{bmatrix} = \begin{bmatrix} a_1 \circ R_1 \\ a_2 \circ R_2 \\ \cdots \\ a_5 \circ R_5 \end{bmatrix}$$

Project management capability maturity evaluation result is:

$B = A \circ R = (b_1, b_2, \cdots, b_5)$, $\sum_{i=1}^5 b_i \neq 1$, then

take the B normalization process.

(3) Project management capability maturity final e-

valuation score is decided by the vector inner product of B and V ($P = B \cdot V$). When $P \leq 49$, project management capability maturity is the initial stage, $50 \leq P \leq 69$ is the growth stage, $70 \leq P \leq 79$ is the management level, $80 \leq P \leq 89$ is the optimization level, $90 \leq P \leq 100$ is the synergistic level. The evaluation of the maturity level is to select the appropriate BP implementation so as to achieve the new KPA to reach the target of the new level requirements, and so on, prompting the company to fly project management capability maturity level from low to high, gradually improving project management design comprehensive strength.

7 Conclusions

Using a software industry capability maturity model and project management maturity model for reference, we studied the project management capability of a large aircraft main manufacturer preliminarily, designed a project management capability maturity evaluation index system and used fuzzy mathematics theory to evaluate it based on the evaluation of the maturity level to get the ability to select the best practices. of course, the current study is still in theoretical exploratory stage, without practice. Factors considered in the research process are also not perfect and need further study to improve this system.

The next step in our research will other five core capabilities of select the large aircraft main manufacturer, further make comparative analysis and empirical research on its maturity model and evaluation system, so as to improve the core capability maturity model and evaluation system of a large aircraft main manufacturer.

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