Research on Project Approval Evaluation Index of Highway Engineering Metering Technical Specification Based on Delphi Method

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Abstract. As the standard and basis for metrology, testing and calibration, highway engineering metrological technical specifications play a key role in promoting highway metrology. It is an important part of the national metrological technical norms, and it is of great significance to evaluate it in the project approval process. Based on the literature research and Delphi method, this paper aims to find out the project evaluation indicators of the highway engineering metrological technical specification project, and provide decision makers with a scientific evaluation method for reviewing projects.

1. Introduction
The testing equipment used in road engineering, roads, bridges and traffic engineering involves nearly 200 kinds with highly professional features, most of which are special instruments for compound parameters, comprehensive quantities and dynamic online measurement. In the early years, only a single physical quantity is measured, such as mass, length, and other general measurement technical specifications, which is far from satisfying the current testing and calibration requirements. Using higher technical measurement specifications is an important safeguard measures for modern metrological work. With the attention of the state and industry authorities on the highway measurement work, it is of great significance to carry out the research on the evaluation index of the highway engineering measurement technical specifications for the project preparation and management of the measurement technology specification.

2. Research status at home and abroad
At present, there is no research on the evaluation index of highway engineering metrological technical specifications. In the past years, the evaluation of highway engineering measurement technical standard project was carried out by means of expert meeting. This method is subjective and lacks scientific and reasonable index explanation, so it is difficult to form an evaluation index content that gives consideration to innovation. There are some relevant policy documents, such as the National Standards Committee on the issuance of the “Recommended National Standards Evaluation Method (Trial)”, the “Science and Technology Evaluation Method” formulated by the Ministry of Science and Technology, and researchers in other field such as Wang Peng establish evaluation indexes of local standards of rural tourism projects based on DEMATE model and conduct quantitative evaluation, put forward the concrete solution according to the results of the quantitative evaluation of customer satisfaction measures [1], etc. These policies and research results cannot be directly applied to the highway engineering field. The proprietary technical characteristics of roads, bridges, tunnels and
traffic engineering in highway engineering determine that the formulation of evaluation indicators should be based on the analysis of technical attributes and management demands of highway engineering instruments and equipment. Therefore, it is very important to carry out researches on the evaluation indicators for the highway engineering metrological technical standard project.

This paper is a scientific sorting and research on the evaluation index of highway engineering metrological technical specifications. For the first time, the content of literature research indicators is used, and basing on the Delphi method, the evaluation indicators are evaluated and the content of the evaluation indicators is carried out.

3. Using literature research method for initial identification of evaluation indicators such as measurement management demands and technical attributes

The literature research method is an ancient and full of scientific research methods [2], which has advantages of safe, effective, fast, free, save money and time, and extensive channels. Literature research is an important part of decision-making management in the early stage of project establishment. Its purpose is to review the reliability, authenticity and objectivity of the project feasibility study, and provide a scientific basis for the approval decision of the competent authorities [3]. The formulation and revision of highway engineering measurement technical specifications should not only satisfy the requirements of advanced technical level but also be sustainable development. Only by satisfying these two requirements can make the specifications be more feasible, and only the new technique based on scientific and reasonable prediction and architecture design can make the development of highway measurement field more reasonable.

Analyze the measurement management needs in highway engineering, mainly obtain the relevant evaluation indicators from national policies, laws and regulations to the scope of application and regional development strategy, the promotion of national economy and social development, the necessity, the corresponding management catalogue of instrument and equipment, and matching the relationship of three-year plan, advancement of research objectives, necessity and advancement of revision, etc.

The technical attribute indicator identification mainly analyzes the key technical evaluation indicators such as measurement technical parameters, characteristics, environment, results, testing methods, verification steps, uncertainty, and data verification of highway and bridge traffic engineering equipment involved in highway engineering.

This article is based on the "Guidelines for the Standardization of 2018" (National Standards Committee Comprehensive [2018] No. 19), JJF1002-2010 "Rules for the Preparation of National Metrology Verification Procedures", JJF1071-2010 "Rules for the Preparation of National Calibration Specifications", and the 13th Five-Year Development Plan for Transportation The policy documents and 95 published highway engineering metrological technical specifications have been reviewed and compiled, and the WBS hierarchical structure of the technical specifications of the core technical properties and management requirements is obtained. (see Table 1)

Table 1 Contents of evaluation indicators in the project declaration stage determined based on the literature research method

| First level index A | Two level index B | Three level index C                        |
|---------------------|-------------------|-------------------------------------------|
| Establishment and  |                   | Degree of integration with regional       |
| Evaluation of       | Management needsB1| development strategy C1                    |
| Technical          |                   | Promotion of national economic and social  |
| Specification for   |                   | C2                                         |
| Highway            |                   | Compliance with relevant laws and         |
| Engineering        |                   | regulations C3                            |
| Measurement        |                   | Necessity C4                               |
|                     |                   | Catalogue of Management of Corresponding |
|                     |                   | Instruments and Equipment C5              |
|                     |                   | Is it included in the three-year plan? C6 |
|                     |                   | The relationship between planning and     |
|                     |                   | management needs C7                       |
| Technical attributeB2 | Advance of Research ObjectivesC8 |
|----------------------|----------------------------------|
|                      | RevisionC9                       |
| SummaryC10           |                                  |
| Main Technical ContentsC11 |                  |
| Uncertainty evaluationC12 |                  |
| Test verification contentC13 |                  |
| Metrological Performance RequirementsC14 |                  |
| General technical requirementsC15 |                  |
| Control of measuring instrumentsC16 |                  |
| Postscriptural MatterC17 |                  |
| declared qualityB3   | Is the schedule reasonable? C18  |
| Key issues to be addressedC19 |                  |
| innovation abilityC20 |                  |
| Quantity Transfer CapabilityC21 |                  |
| Technical maturityC22 |                  |
| The relationship between technical attributes and management requirementsC23 |                  |
| Terminology and units of measurementC24 |                  |
| RangeC25             | The structure is rigorous and hierarchical, and the full text is coordinated and consistent.C26 |
|                      | Expressing the name of measurement unit in accordance with the provisions of the StateC27 |
|                      | Does the Graph, Table and Mathematical Symbol Writing Meet the RequirementsC28 |
| Personnel and undertaking unitsB4 |                  |
| Rationality of Project Team StructureC29 |                  |
| Undertaking Technical Capability and R&D Conditions of UnitsC30 |                  |
| Is it an industry-related measurement technology institution? C31 |                  |
| Comprehensive Quality of Project LeadersC32 |                  |
| AchievementsB5       | Forms of research resultsC33     |
|                      | Intellectual Property Rights of ResultC34 |
| Allocation of fundsB6 | Is the fund raising and arrangement reasonable? C35 |
| Economic, Social and Environmental BenefitsB7 |                  |
| The Impact on the Transfer of Quantity Value and the Estimation of the Economic Benefit Produced in the FutureC36 |                  |
| Does it have a positive social impact on the development of the industry? C37 |                  |
| Promotion to Related IndustriesC38 |                  |
| Consistency with the Formation, Upgrading and Development of Regional IndustriesC39 |                  |
| Is it in line with the green environmental protection and low consumption? Is it conducive to the environment? C40 |                  |
| risk factorB8        | Technology riskC41               |
|                      | Management riskC42               |
|                      | Policy riskC43                   |
|                      | Interest rate riskC44             |
|                      | Public Opposition to RiskC45     |
|                      | market riskC46                   |
|                      | Competitive Risk of Homogeneous ProjectsC47 |                  |
|                      | Regional Comprehensive Competition RiskC48 |                  |
The initial identification of the project considers the characteristics of highway measurement technical specifications. It is necessary to further divide the scientific research evaluation indicators, and exclude other evaluation indicators that do not exist or have little impact. After combing the analysis, 8 secondary indicators and 48 third-level indicators are obtained.

4. Project risk secondary identification based on Delphi method
The Delphi method is a tool in project management and an important method for expert investigation. It comes from the myth of ancient Greece. Its distinctive advantages are: anonymity, statistics, feedback, and also includes multiple rounds of consultation and gradually merging. Generally, the expert opinions are consulted through multiple rounds of expert questionnaires, and finally conclusions are drawn. Delphi method has been successfully applied to many fields and has obtained good results.

The basic steps of the Delphi method are as follows: 1) Determine the topic, prepare the background material, design the questionnaire, and select the appropriate expert group. All the evaluation indicators should be mentioned in the questionnaire. 2) Issue the questionnaire to the expert group, solicit the opinions of the experts and conduct centralized statistical processing; this step adopts multiple rounds of consultation methods. That is to say, based on the first expert opinion, the questionnaire is corrected and sent to the expert for consultation. If the consensus of a certain expert is high, the investigation is ended and statistical processing is performed to form a certain opinion. Then, the result of the last survey is the content of the evaluation indicators selected.

In this paper, the Delphi method is used to identify the evaluation indicators of the highway engineering metrological technical specification project at the application stage, and relevant experts are invited to conduct questionnaire survey.

4.1 Establish an initial questionnaire
Use the contents of Table 1 to form the evaluation factors for the project evaluation of highway measurement technical specifications, and determine the initial measurement content, and then conduct a questionnaire survey. The research object is the person in charge of the competent department of the industry, the person in charge of the measurement technology organization at all levels, the management personnel in charge of metrology research in the university, and the senior measurement expert, which is a total of 30 people. The basic information of experts surveyed by Delphi method is shown in Table 2 below.

| Research object                     | Number | Proportion (%) |
|-------------------------------------|--------|----------------|
| Gender                              |        |                |
| male                                | 24     | 80%            |
| female                              | 6      | 20%            |
| Age range                           |        |                |
| 30 Under age                        | 0      | 0              |
| 30~39 years old                     | 6      | 20%            |
| 40~49 years old                     | 15     | 50%            |
| 50 Over age                         | 9      | 30%            |
| Relevant working experience         |        |                |
| 1 Year and below                    | 0      | 0              |
| 1~5                                 | 0      | 0              |
| 5~10                                | 6      | 20%            |
| 10 More than year                   | 24     | 80%            |
| Technical Specification for Highway Measurement | 0      | 0              |
| Number of project participants      |        |                |
| 1~5                                 | 3      | 10%            |
| 6~10                                | 27     | 90%            |

The main purpose of this survey on the research object is to examine and correct the measurement content of the evaluation indicators of the initial highway engineering measurement technical specification, and to remove the evaluation factors that are not necessary for consideration based on
the characteristics of highway engineering measurement technical specifications. The entire questionnaire lasted for one month. A total of 30 questionnaires were distributed and 30 questionnaires were actually collected. This shows that the participation of experts is very high.

A questionnaire was designed based on the evaluation indicators of 48 highway engineering metrological technical specifications. The content of the questionnaire is divided into 5 sections, including 1) project background introduction, project research purpose; 2) expert background introduction; 3) highway engineering measurement technical specification project evaluation index meaning and content introduction; 4) evaluation index score table;) Supplementary comments section. The initial questionnaire survey includes two aspects: the selection content and supplementary opinions of the experts on the project evaluation indicators.

After receiving the questionnaire, the experts will score the relative importance of each of the three indicators in the questionnaire. According to the degree of importance, the experts are divided into six important contents: important, important, important, generally important, less important, and unimportant. Corresponding to 10 points, 8 points, 6 points, 4 points, 2 points, 0 points. At the same time, experts also give familiarity with the content of the evaluation indicators and the basis for judgment. The judgment basis is divided into 4 categories: practical experience, theoretical analysis, domestic and international technical understanding, and intuitive sensation, corresponding to 1, 0.75, 0.5, 0.25, respectively. The familiarity is also divided into 5 categories: very familiar, familiar, generally familiar, not familiar, unfamiliar, corresponding to 1, 0.8, 0.6, 0.2, 0 respectively.

4.2 Expert consistency test

4.2.1 Authority test

Choosing expert is the key point to the success or failure of the Delphi method. Expert level and experts’ familiarity with second-level index content are used to determine the degree of expert authority. In this paper, the average value of expert level and expert index content familiarity is selected as the final judgment value. The expert consistency test is carried out in two rounds. The degree of expert authority is shown in Table 3 below. Among them, the first round of consistency test results is 0.857, the second round of test results is 0.872, both larger than 0.7, the value is acceptable reliability. It can be seen that the above-mentioned expert survey has a high degree of authority, and the expert evaluation results are credible.

| Two level index | Judgement basis | Familiarity | Authority level | Judgement basis | Familiarity | Authority level |
|-----------------|-----------------|-------------|-----------------|-----------------|-------------|-----------------|
| Management requirements B1 | 0.837 | 0.891 | 0.864 | 0.879 | 0.887 | 0.883 |
| Technical attributeB2 | 0.855 | 0.893 | 0.874 | 0.891 | 0.895 | 0.893 |
| Declared qualityB3 | 0.862 | 0.87 | 0.866 | 0.876 | 0.891 | 0.8835 |
| Personnel and undertaking unitsB4 | 0.871 | 0.89 | 0.8805 | 0.878 | 0.883 | 0.8805 |
| AchievementsB5 | 0.829 | 0.88 | 0.8545 | 0.876 | 0.91 | 0.893 |
| Allocation of fundsB6 | 0.813 | 0.893 | 0.853 | 0.82 | 0.891 | 0.8555 |
| Economic, Social and Environmental BenefitsB7 | 0.82 | 0.88 | 0.85 | 0.834 | 0.89 | 0.862 |
| risk factorB8 | 0.805 | 0.823 | 0.814 | 0.826 | 0.825 | 0.825 |
| mean value | 0.8365 | 0.8775 | 0.857 | 0.86 | 0.884 | 0.872 |
4.2.2 Test of harmony coefficient
The Kendall's Harmony Coefficient (Kendall W) is an indicator used to examine the degree of consistency of multiple experts. It is one of the important metrics for applying the Delphi method to screen the indicator system. The basic formula of the Kendall Harmony Coefficient W is:

$$W = \frac{1}{12K^2(N^3 - N)} \left( \sum R_i^2 - \frac{1}{N} \sum R_i^2 \right)$$

In the above formula, K is the number of assessors, N is the number of objects to be assessed, and Ri is the sum of the K numbers of the i-th evaluated object.

The value of W is [0, 1]. The larger the W value, the more consistent the scores between experts, W=1 means that the expert opinions are completely consistent, and W=0 means that the expert opinions are completely inconsistent. The formula (1) was calculated using SPSS software, and the W values of the two rounds of surveys were 0.837 and 0.878, respectively. Obviously, the opinions of the experts in the two rounds of investigation are consistent.

4.2.3 Analysis of the survey results
The first round of survey factors is the 48 index factors of the literature research method, collecting the first round of expert opinions, and removing the evaluation indicators with lower survey scores, such as the third-level indicators of management factor c42, interest rate factor c44, public opposition factor c45, regional comprehensive competition risk c48, policy risk c43, market risk c46, technical risk c41. The homogenous project competition risk c47 can be combined in the declaration quality b3, so the secondary indicator risk factor b8 can be removed. In the second survey, the rational factors c35 of fund raising and financing arrangement were incorporated into the declared quality b3, and the secondary indicator fund allocation b6 was removed. The third-level indicator c37 determining whether it has a positive social impact on industry development, the driving force indicator of the relevant industry c38, and the indicator of integration and development of the regional industryc39, etc., all merge into an indicator c37 of whether has a positive social impact on industry development. Through two rounds of expert evaluation, the standard of expert consistency was finally reached, and a total of 39 three-level index factors were formed, as shown in Table 4 below.

Table 4 Final results of evaluation indicators for the reporting phase of highway engineering metrological technical specifications

| First level index A | Two level index B | Three level index C |
|---------------------|-------------------|---------------------|
| Establishment and Evaluation of Technical Specification for Highway Engineering Measurement | Management needsB1 | Degree of integration with regional development strategy C1 |
|                     |                   | Promotion of national economic and social development C2 |
|                     |                   | Compliance with relevant laws and regulations C3 |
|                     |                   | Necessity C4 |
|                     |                   | Catalogue of Management of Corresponding Instruments and EquipmentC5 |
|                     |                   | Is it included in the three-year plan? C6 |
|                     |                   | The relationship between planning and management needsC7 |
|                     |                   | Advancement of Research ObjectivesC8 |
|                     |                   | RevisionC9 |
| Technical attributeB2 |                   | SummaryC10 |
|                     |                   | Main Technical ContentsC11 |
|                     |                   | Uncertainty evaluationC12 |
|                     |                   | Test verification contentC13 |
|                     |                   | Metrological Performance RequirementsC14 |
5. Conclusion
In the “13th Five-Year” development plan for transportation standardization, “Exploring the establishment of a standard evaluation index system to form a stable and long-term evaluation mechanism. [4]” illustrates the importance of standardized evaluation work in the development of the 13th Five-Year Standardization. The highway engineering metrological technical norms serve the standards and are part of the standardization work. The research evaluation indicators for the highway engineering metrological technical specifications will provide reference for the establishment of the transportation standardization assessment index system.

In this paper, the evaluation indicators of the highway engineering metrological technical specification project are divided into three levels: the first-level indicator is the highway engineering measurement technical specification project evaluation, and the second-level indicator mainly includes six categories, which are management requirements, technical attributes, declaration quality, personnel...
and responsible unit’s situation, achievements, economic and social benefits, the third-level indicators sub-content includes 39 categories. The third-level indicators fully reflect the main factors in the evaluation of the highway engineering metrological technical specification project. Although the index screening in this paper determines the content of the indicators in the approval process, and the expert consistency test coefficient meets the requirements, it is not specific to the technical specifications of highway engineering measurement. In a specific process of project approval, project evaluation should be aimed at specific concrete analysis of metrological specification content of highway engineering.

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