

# Research on Transforming into Evaluation Model based on Synchronization Engineering Technology Review Data

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**Abstract:** This paper introduces the model transformation methods for synchronous engineering technology review data. Listing all the categories of the technology review by analyzing the logical structure and review data of synchronous engineering technology review. This research classifies and summarizes five fundamental evaluation models by using data structure, and focus on expounds the methods of transforming review data into evaluation models.

**Keywords:** Synchronization Engineering, technology review, evaluation model, transformation methods

## 1. Introduction

With the rapid development of automobile industry, the automation rate of automotive production is rising, but whether the research and development of new automobile products meet the requirements of the production process still requires manual intervention. It often needs to manually review process to evaluate the technology review data. The above process is inefficient and high-cost, manual review may have errors and other problems.

This paper presents a method of transforming technology review data into evaluation model by using computer data structure, which endows re-usability to the review standard data and improves the efficiency of technology review. This study can be used as a preliminary exploration to digitize and automate the technology review process.

## 2. Logic Analysis of Technology Review

### 2.1. Introduction of Synchronous Engineering Technology Review

The concept of synchronous engineering development is that design and production should be closely combined at the initial stage of new product development. The traditional way of combination is that the research and development department provides automotive product design data, and the production department fills in the technology review form based on the two dimensions of maneuverability review and predictability review. Problems and causes in the design data were described and analyzed, and countermeasures and requirements were put forward based on the existing problems [1]. Finally, the relevant departments shall provide the process countersign to complete the technology review. An example of a traditional process review data is shown in Figure 1:

Gist		FAW_A platform _ System Function Development Requirements _ Body control System /FCC_BCM_Diag_Spec		level	S	M
dimension	Problem description and cause analysis		Countermeasures and requirements			
M	1. Vehicle status requirements	In section 4.2, the voltage requirement for the normal operation of the reverse lamp is not reflected; The power supply status of the backlight is not reflected.	It is suggested to increase the voltage requirement for the normal operation of the backlight; It is necessary to increase the power supply state requirement for the backlight			
R	2. The system input signal status can be	No backlight function input signal identifier is defined and cannot be queried -- see section 7.2 of FCC_BCM_Diag_Spec	It is recommended to add the tap signal and power mode and read it through 22 XX diagnostic service			

Figure 1: Traditional technology review data.

### 2.2. Types of Technology Review

Due to the diversity of automotive product design data and different review needs [2], process review can be divided into the following types:

(1) Document inspection consistency review. It reviews whether the design document contains the key information of the production process;

(2) Fault verification consistency review. It reviews whether the automotive product design includes the required diagnostic trouble code, such as voltage monitoring logic, communication monitoring logic, configuration fault logic and fault code clearance logic;

(3) Diagnostic process consistency review. It reviews key data items in diagnostic specification design documents, whether DID (data identifier) has been defined, whether the description of DID related items is consistent, etc.;

(4) Function model consistency review. It reviews the key data items under a certain function of the model by function unit, such as function enabling conditions, vehicle state, environmental temperature and control unit working logic, etc.;

(5) Information security consistency review. It reviews key data items related to information security, such as post-manufacturing data transmission, cloud service data transmission and calibration data transmission.

### 2.3. Logical Structure Division of Technology Review

There is a logical mapping relationship between automobile type, controller and function in process review, in which the relationship between automobile type and controller is one-to-many, and the relationship between controller and function is one-to-many. A function may exist in multiple controllers, and a function is strongly associated with a controller in a specific automobile type. In technology review, function and controller can not exist without the automobile type so “automobile type to controller to function” three logical structure is the basis of technology review.

An automobile type can contain multiple technology review categories. The logical structure layer associated with technology review of categories is different and can be selected within a limited range, but one technology review can only be associated with one logical structure layer. The detailed association are as follows:

(1) The document inspection consistency review is default associated with models, can be refined to a controller or a function based on the review requirements.

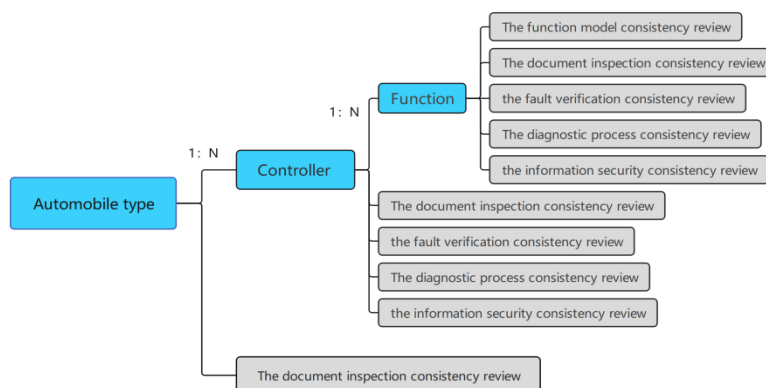
(2) By default, the fault verification consistency review is associated with the controller, which can be refined and associated to a certain function based on the review requirements.

(3) The diagnostic process consistency review is associated with the controller by default, which can be refined and associated to a certain function according to the review requirements.

(4) The function model consistency review is associated with functions by default and cannot be changed.

(5) By default, the information security consistency review is associated with a controller, which can be refined and associated to a function based on the review requirements.

The logical structure among vehicle type, controller, function and process review categories is shown in Figure 2:



*Figure 2: Logical structure diagram of technology review.*

### **3. Analysis of Technology Review Data**

#### **3.1. Overview of Evaluation Model**

The evaluation standard in synchronous engineering technology review is jointly formulated by synchronous engineering experts and automobile production line experts [3]. This standard replaces the two data items of "problem description and cause analysis" and "countermeasures and requirements" in the traditional technology review form. It is the evaluation criteria of the content to be reviewed in the technology review, composed of natural language or numerical values. By analyzing the data of the traditional technology review data sheet, the evaluation standard can be divided into numerical class, boolean class, field class, diagnostic trouble code class and DID class.

Therefore, in the process of modeling the review standard data, evaluation models can be defined as the following: value model, boolean model, field model, diagnosis trouble code standard model, DID model. The following sections will elaborate on the transformation methods and composition specifications of each model.

#### **3.2. Review Category and Review Model**

A technology review category can contain multiple standard review data, and there is a one-to-one correspondence between the standard review data and the review model, so the same technology review category can contain multiple review models. The review model in similar technology review is relatively fixed, but it can also be selected based on specific review requirements. For example, DID model can be used in the consistency review of diagnostic process in most cases, and in a few cases, when review data cannot be covered by DID model, other models can be selected [4].

#### **3.3. Value Model**

##### **3.3.1. Transformation Method of the Value Model**

In the technology review data, vehicle steering speed, vehicle speed, vehicle engine water temperature, battery power-on time, environmental temperature, vehicle levelness and environmental light illumination under the dimension of vehicle state requirements are all numerical data. Therefore, the technology review data of the same type above can be transformed into the value model based on the standard name, standard value and unit type.

##### **3.3.2. Composition and Review Criteria of the Value Model**

The value model consists of three parts: standard name, standard value and unit type. The standard value can be divided into numerical standard value and range standard value. Both standard value and unit type become the evaluation criterion of this model.

(1) Standard name defines the name of the evaluation standard. The data type is string. Using the standard name to match the content to be reviewed to ensure the accuracy of technology review.

(2) Standard value defines the size of the standard value. The data type is numeric. The review engineers can enter one fixed value as standard value (fixed value standard) or two values (range value standard) to delimit the range of standard value. During the evaluation, it can be judged whether the value is the same or in the range based on the requirements. If the value is different or not in the range, it is deemed that the evaluation item does not pass.

(3) Unit type defines the unit of the standard value. The data type is string. During the evaluation process, it is necessary to verify whether the units to be reviewed are completely consistent with the units of the standard model. If they are inconsistent, it is deemed that the evaluation item does not pass.

##### **3.3.3. Example of the Value Model**

Evaluating the vehicle state requirement under the evaluation system function maneuverability dimension is to transform "vehicle speed 0 m/s" into value model. The evaluation data is transformed according to the value model structure "standard name + fixed type standard value + unit type", the results are as follows:

Standard name: Vehicle speed

Fixed standard value: 0

Unit type: m/s

### **3.4. Boolean Model**

#### **3.4.1. Transformation Method of the Boolean Model**

Boolean type data is one of the common data types in technology review, and its data requirements conform to duality. For example, the data items could be yes or no, on or off, open or close. they can be transformed by using the structure of boolean model, such as vehicle start/flame-out, power gear state, vehicle air conditioning state, and vehicle electrical switch state under the dimension of vehicle state requirements.

#### **3.4.2. Composition and Review Criteria of the Boolean Model**

Boolean model consists of three parts: standard name, standard value and semantic set of standard value. The standard name matches the content to be reviewed with the corresponding review standard model. Standard values match the boolean model to the semantic set of standard values. The semantic set of standard value is the criterion of boolean model.

(1) Standard name defines the exact name of the evaluation standard. The data type is string. Use the standard name to match the content to be reviewed to ensure the accuracy of process review.

(2) Standard value defines the exact content of the standard value. The data type is string. A standard value is matched as a label for the standard value semantic set.

(3) Semantic set of standard values is preset by boolean model and automatically matched. If a standard value exactly matches a field in a semantic set, all fields in that semantic set are considered synonymous with the standard value. This semantic set can be used to compare with the items to be reviewed in the technology review. If there is no matching item, it is deemed that the evaluation item does not pass.

#### **3.4.3. Example of the Boolean Model**

For example, in the requirements of vehicle state evaluation for system function maneuverability, the evaluation standard data is "Vehicle air conditioning status off". The results of transforming the above review data into the model according to the structure of Boolean model "standard name + standard value + semantic set of standard value" are as follows:

Standard name: Vehicle air conditioning status

Standard value: Off

Semantic set of standard values: off, closed, does not open, shut, turn off, switch off

### **3.5. Field Model**

#### **3.5.1. Transformation Method of the Field Model**

Any string data that needs to be reviewed in technology review can be transformed into field model by extracting key character information. In addition, if the review standard data of a complex structure cannot be classified into the other four review models, the key information can be extracted from the original data as key fields to transform it into a field model. Therefore, the evaluation criteria data composed of strings or any data to determine whether it contains key field information can be transformed into a field model.

#### **3.5.2. Composition and Review Criteria of the Field Model**

The field model consists of several field modules. This model is editable, which can be composed of one or more fields to form the evaluation criteria of this model.

(1) Field 1 defines the content or keywords of the evaluation criteria. The data type is string. If the content to be evaluated is inconsistent with this field, the evaluation will not pass.

(2) Field X can be added by the review engineer based on the actual length of the review standard. The data type of field X is a string. If the content to be evaluated is inconsistent with this field, the evaluation will not pass.

(3) There are two types of fields: key fields and combination fields. Key fields are the core fields of

the review criteria. If the content to be reviewed contains key fields, it is deemed that the review has passed. The combination field defines multiple rules for the evaluation, and the combination of the combination fields is a parallel relationship. The combination of multiple fields becomes one evaluation criterion. As long as the content to be evaluated contains one of multiple combination fields, it is deemed that the evaluation item pass.

(4) Multiple fields are defined as the evaluation criteria according to the evaluation standard data, the number of fields is not limited.

(5) In the process of comparing review data with model fields, an algorithm can be introduced to calculate the matching percent to improve the accuracy of technology review [5].

### ***3.5.3. Example of the Field Model***

Evaluating the system output signal status of the function predictability evaluation, the evaluation standard data of the engine idle start and stop signal is “It should reflect the engine idle start and stop permit function input signal identifier”. The data in this sentence are all composed of strings, so long strings can be decomposed into key strings and converted into field models as follows:

Field 1: Engine idle start and stop

Field 2: License function input

Field 3: Signal identifier

## ***3.6. Diagnosis Trouble Code Standard Model***

### ***3.6.1. Transformation Method of Diagnosis Trouble Code Standard Model***

In the process of fault verification consistency review, it is necessary to conduct multiple trouble code review and verification to judge whether the design related to the trouble code of the Research and development department meets the requirements of the production department.

In the technology review of fault verification, the review standard data should be verified whether the trouble code is consistent, such as MRR system blindness, loss of communication with EPS message, loss of communication with ACU\_YAW message, loss of communication between MRR and GPS message, etc. Therefore, the original data can be split and solidified into the diagnosis trouble code standard model according to the description of trouble code and trouble code itself.

### ***3.6.2. Composition and Review Criteria of the Diagnosis Trouble Code Standard Model***

The trouble diagnosis standard model consists of two parts: DTC (diagnosis trouble code) and DTC description. The trouble code is taken as the criterion of this model.

(1) The trouble code is a string of letters and digits. It is the unique identifier of the diagnosis trouble code standard model and has uniqueness and non-redundancy. If the trouble codes are inconsistent, it is considered that the review item does not pass.

(2) DTC description is a detailed description of the trouble code. It is a supplementary description of the standard data for this type of review. There is a one-to-one correspondence between fault description and fault code, which is used for reference in manual review.

### ***3.6.3. Example of the Diagnosis Trouble Code Standard Model***

For example, if the trouble codes under the inspection dimension of system function predictability are reviewed, the review items are communication logic faults and communication loss between ATC packets. The evaluation standard data is “U116487 No ATC\_2 message is received”. U116487 indicates the trouble code, and No ATC\_2 message is received indicates the trouble code description. According to the diagnosis trouble code standard model, the results are as follows:

Trouble code: U116487

Description: No ATC\_2 message is received

## ***3.7. DID Model***

### ***3.7.1. Transformation Method of the DID Model***

In the process of the diagnostic process consistency review, multiple DID verification is required. For

example, in the dimension of system function predictability review, the system execution state can be queried, the system output state can be controlled, and the system input signal state can be queried, and other review items need to read and verify DID. Therefore, the review of DID class can split the content description of DID and DID into two parts and transform it into DID model.

### **3.7.2. Composition and Review Criteria of the DID Model**

DID model consists of two parts: DID and DID content description. DID and DID content description jointly become the evaluation criteria of this model, that is, when DID is consistent, content description is also consistent.

(1) DID refers to the identifier code of DID. It consists of characters of a specified length. The data type is string. If DID is different, the evaluation item will not pass.

(2) DID content description defines the meaning of DID. The data type is string. This string contains a detailed description of DID. If the DID content is different in the technology review process, it is deemed that the review item fails.

### **3.7.3. Example of the DID Model**

Reviewing the system execution status can be queried in the function predictability review, the standard data is "DF53 IPB Dynamic Test". The transformation result of DID model described in terms of DID+DID content is as follows:

DID: DF53

DID Description: IPB Dynamic Test

## **4. Conclusions**

In this paper, the logic and data of technology review in synchronous engineering are analyzed, the logical structure between technology review category and traditional process review is sorted out, and a method to transform the standard data of synchronous engineering into digital model is proposed. This method contains five basic data models, which can be applied to five types of synchronous engineering technology review at present. Meanwhile, it also provides re-usability for traditional standard data and can improve the efficiency of technology review. Based on the digitization of the review standard data, the transformed model can be used to implement the automatic technology review of synchronous engineering process, which greatly improves the work efficiency of the review engineers.

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