Dynamic BOM Construction Technology and Application Based on MBD

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Abstract. In view of the problem that the information transfer based on unstructured documents and non-dynamic BOM results in the limited efficiency and precision of spacecraft assembly configuration management, a dynamic EBOM construction technology based on MBD model is proposed. By adding assembly Configuration attributes to MBD model, it can cover the data requirements of spacecraft assembly process. The EBOM is constructed by extracting Assembly structure tree, product and configuration attributes of MBD assembly model. The dynamic EBOM is constructed by changing the value of the attributes describing the assembly Configuration in the EBOM. On this basis, through the comparison between the EBOM and the implementation BOM, the Configuration of spacecraft assembly is quantitatively controlled.

1. Introduction
With the development of digital design and manufacturing and assembly technology based on MBD, three-dimensional digital design and manufacturing has been widely realized in international aerospace enterprises represented by Boeing, Airbus and Lockheed Martin, and great success has been achieved[1,2]. MBD model has replaced two-dimensional drawings and become the only manufacturing basis for product development[3].

At present, China enterprises have achieved some results on applying the MBD technology[4,5]. However, the MBD model does not run through the whole assembly process, mainly reflected in the backwardness of EBOM construction technology[6]. Due to The attributes describing assembly Configuration in MBD model are incomplete, the EBOM information extracted from MBD is incomplete, and can not cover the development needs of assembly department. A large number of descriptive unstructured documents need to be assisted. The information transfer mode based on a large number of unstructured documents needs to consume a great deal of energy for sustained statistics, verification and comparison of the technical status information of products[7]. At the same time, during the whole assembly process, the assembly Configuration is changing dynamically, and EBOM, as a snapshot of this Configuration, must be in a dynamic change. At present, the change of Configurations is transmitted through unstructured and descriptive documents such as technical status requirements. Unstructured and non-dynamic EBOM directly limits the efficiency and precision of spacecraft assembly technology management.

In this paper, assembly Configuration attributes are added to MBD model to cover the data requirements of assembly process, structurally EBOM is constructed by extracting product structure, model objects and attributes of spacecraft MBD model, dynamic EBOM is constructed by changing the values of the attribute describing the assembly Configuration. On this basis, the spacecraft
assembly Configuration is controlled quantitatively and intuitively by comparing the EBOM with the implementation BOM, which proves great beneficial effect on configuration management.

2. MBD construction

MBD is a method which uses three-dimensional model to fully express product definition information. This technology defines three-dimensional design information, three-dimensional manufacturing information and management information together into the three-dimensional digital model of products[8].

The core idea of MBD technology is to make full use of three-dimensional model to realize product information sharing and direct transmission of digital manufacturing and assembly information, to meet the more convenient, direct and efficient use needs of the product development cycle, and to maintain consistency and trace ability in the design, process planning, production and inspection of MBD model.

In order to cover the requirement of configuration control of spacecraft assembly, and to form the appropriate data structure to support the effective expression of all kinds of configurations, based on the geometric information, non-geometric information and management attribute of the traditional MBD model, this paper constructs the assembly configuration attributes in the MBD model, an MBD system for configuration management of spacecraft assembly is constructed on the basis of these attributes. The MBD system is shown in Figure 1.

![Figure 1. MBD system for configuration management of spacecraft assembly](image)

During the construction of MBD model, in order to reduce data redundancy and facilitate statistical analysis, different types of products of spacecraft contain different attributes, the MBD model attributes Configuration Table is showed in Table 1.

| No | Product type | Geometry Model | Coordinate System | mass property | annotation | Material | notes | Product name | code number | qualification status | Part version | Installation state | Thermistor Sticking state | Connector plug state | Grounding state | Accessory Installation state | Accuracy measurement state | Leak rate measurement state |
|----|---------------|----------------|-------------------|---------------|-----------|---------|-------|--------------|-------------|---------------------|--------------|-----------------|--------------------------|-------------------|---------------|-----------------------------|------------------------|------------------------|
| 1  | equipment     | ○ ○ ○ ○ ○ ○ ○ | ○ ○ ○ ○ ○ ○ ○ | ○ ○ ○ ○ ○ ○ | ○ ○ ○ ○ | ○ ○ ○ | ○ ○ ○ | ○ ○ ○ ○ ○ ○ | ○ ○ ○ ○ ○ ○ | ○ ○ ○ ○ ○ ○ | ○ ○ ○ | ○ ○ ○ | ○ ○ ○ | ○ ○ ○ | ○ ○ ○ | ○ ○ ○ | ○ ○ ○ | × |
BOM is widely used in manufacturing system to express product structure and related information. It is an important document for design and production. It is also the key data for data sharing and information integration. In traditional sense, BOM is the list of all sub-assemblies, parts, raw materials and every part needed for manufacturing an assembly\[9\]. With the advancement of manufacturing informationization, the meaning of BOM is more and more extensive. Accordingly, BOM is no longer just a simple set of parts and materials, it can contain all valuable attribute information of parts and components.

Spacecraft dynamic BOM information comes from the MBD assembly model. The MBD assembly model is composed of a series of MBD component models, together with annotations and attribute data expressed in text.

By extraction of Assembly structure tree, product and configuration attributes of the spacecraft assembly MBD model, we create the structured EBOM, by changing status of each attributes of EBOM, a dynamic BOM describing the Configuration of spacecraft assembly indifferent phase of product development is established, and the dynamic-structured representation of spacecraft assembly configuration management is achieved.

![Figure 2] Dynamic BOM of spacecraft assembly configuration

4. Spacecraft assembly configuration management

In the development of spacecraft, assembly occupies 30% to 50% of the total working hours, and every step is directly related to the success or failure of the spacecraft\[10\]. Assembly Configuration management is an important mean to ensure the quality of spacecraft assembly. By dividing the assembly process into several phase, when spacecraft arrives at the phase, the assembly configuration of the spacecraft should be set in detail and the implementation results of the configuration should be tracked, to effectively control the configuration of the assembly.

In order to compare the design configuration with the implementation results, the implementation results needs to be collected, the execution record table is added to the assembly process files and released together with the process. The execution record table includes the code number of the product, the execution time of the activity and the value of the configuration attribute after the implementation, which is filled in by the workshop worker during the implementation.

On this basis, we can specify any time, traverse the relevant products in the process system, extract the actual configuration value of each product, the implementation BOM is constructed by summarizing of these information.
By comparing EBOM with implementation BOM, firstly, it can directly review the progress of implementation of spacecraft assembly. Secondly, the difference between design configuration and implementation results can be quickly positioned. It realizes the quantitative management and closed-loop control of spacecraft assembly configuration.

5. Application

Take the installation of equipment as an example, and carry out the application verification of the method in this paper according to the following steps: 1) Build the equipment MBD model, as shown in Figure 3; 2) Extract the assembly configuration attributes information in MBD, and establish the dynamic design BOM excel table according to the assembly configuration requirements in each phase, as shown in Table 2; 3) Establish the execution record table; 4) Export the implementation record to the implementation BOM excel table, compare the design BOM with the implementation BOM, and output the results to the excel table, as shown in Table 3. The prototype system completely verifies the dynamic BOM construction method based on MBD and its remarkable effect in spacecraft assembly configuration management.

![Figure 3. MBD model with assembly configuration information](image)

### Table 2. Dynamic BOM of spacecraft assembly configuration

| Equipment | Initial | Phase A | Phase B | Phase C |
|-----------|---------|---------|---------|---------|
| Installation state | No | Yes | Yes | Yes |
| Connector plug state | X1: No | Yes | Yes | No |
| | X2: No | Yes | No | Yes |
| | X3: No | No | No | No |
| Thermistor Sticking state | T1: No | Yes | Yes | Yes |
| | T2: No | Yes | Yes | Yes |
| Grounding state | No | Yes | Yes | Yes |
| Accuracy measurement state | N/A | N/A | N/A | N/A |
| Accessory Installation state | No | | | |

### Table 3. Compliance table between design and implementation

| Equipment | Phase A Design | Phase A Implementation | Compliance |
|-----------|----------------|------------------------|------------|
| Installation state | Yes | Yes | √ |
## 6. Conclusion

Based on MBD model, this paper puts forward the construction method of spacecraft dynamic BOM, and establishes the application mode of dynamic BOM in the control of spacecraft assembly configuration. By building the prototype system, the dynamic, quantitative and structural management of spacecraft assembly configuration management is realized, and the precision and effectiveness of spacecraft assembly configuration management are improved.

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