

Development of DPM System for CATIA V5

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ABSTRACT

With the increasing use of Data Proto Model, the number of model types and their variations for which the system is employed has increased. Coordination with Bill of Materials systems is now demanded to increase the speed of response of the system from units of weeks to days and to increase the part structure accuracy. In addition, it is also necessary to deal CATIA V5 data. A system for the construction of DPM was therefore developed to help enable the functions of CATIA V5 to be maximally exploited and the data used in drawing issues to be made available as DPM as quickly as possible. During the development process, the accuracy of the shape in DPM was verified, including the accuracy of CATIA V4 data formulated using the previous system, and the data was imported to the new system after conversion for V5. As a result, the period from a drawing issue to the completion of the DPM has been reduced by a maximum of four days, and other departments are able to review specifications ahead of schedule.

1. Introduction

The process of product development in the manufacturing industry today uses 3D computerized models called Digital Mock-ups (DMU) to help enable specifications to be reviewed at the initial stage of the design process by the design, manufacturing, and other departments⁽¹⁾. DMUs called Data Proto Models (DPM) have also proven useful to Honda in product development⁽²⁾. In the construction of a DPM, 3D data for the parts making up a full car are collected, and the data is recorded to enable the completed vehicle to be displayed on a CAD system, with mounting positions being defined using a global coordinate system in the case of 3D data formulated using a local coordinate system. Formerly, a system employing ENOVIA VPM ("VPM" below), manufactured by Dassault Systèmes, S.A., was employed to function as a Product Data Management (PDM) system in order to manage the recorded data and support the construction of the model ("former system" below). The product configuration output from the Bill of Material (BOM) system was recorded, and the DPM was constructed.

However, the following issues arose as a result of expanded application of DPM by users and the transition of the CAD system from CATIA V4 ("V4" below) to CATIA V5 ("V5" below):

(1) System processing speed declined as a result of an increase

in the volume of data due to the construction of DPM for an increased number of models and variations;

(2) An increased frequency of coordination with BOM system data became necessary in order to construct DPM using the most recent parts possible; and

(3) Compliance with V5 and Windows environments became necessary.

This paper will discuss a system development conducted to respond to these issues, which helped to enable the realization of an increased range of applications for DPM.

2. Orientation of System Development

The following development goals were established based on the issues listed above:

(1) The development of a data storage method helping to enable the number of models and variations for which DPM were constructed to be increased;

(2) The realization of an increase in the frequency of coordination with BOM system data from units of weeks to units of days;

(3) The development of a PDM system able to function in Windows environments; and

(4) The realization of scalability in the DPM construction system.

This paper will discuss the results of studies conducted in relation to these four development goals.

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3. Focus Areas in System Development

3.1. Changing the Method of Storage of DPM Data

The product configuration can be considered as being divided into technological BOM data (“BOM information” below), which corresponds to data concerning the applications of the parts, and data concerning the structure of the parts themselves (“parts structure data” below) (Fig. 1).

The BOM information is classified, from the highest level in relation to the model of vehicle downwards, into family, section, and sub-section categories. The application of the parts at the level of helping to ensure functions (“Level 1 parts” below) is managed at this stage. In the parts structure data, the component parts of each of the Level 1 parts are arranged in parent-child relationships from Level 2 to Level N.

In the former system, all of both the BOM information and parts structure data were exploded for each model and connected using the parent-child relationships in each level as link data to form a tree structure; the data was managed using a PDM system.

The only CAD data associated in the parts structure data was data for individual parts that expressed the three-dimensional form. However, because the CAD data for the same individual part could be used multiple times in the same vehicle model, or used in another model, it was necessary to set position data separately to the three-dimensional-form data. Accordingly, the variation in which the part would be applied and the date of its application were set in the link data with the next highest part, in order to function as a coordinate transformation matrix for the local coordinate system of the parent parts of each part (Fig. 2). This tree structure will be termed the “exploded mode” below.

In the exploded mode, when the history of the design changes for the variations and the parts structure for each vehicle model increase, the link data that expresses the tree structure increases as well. Because of this, the responsiveness of the system declines when search conditions are set for the link data and filtering processing is conducted using the date of application and the variation, and this was a factor that impeded the expansion

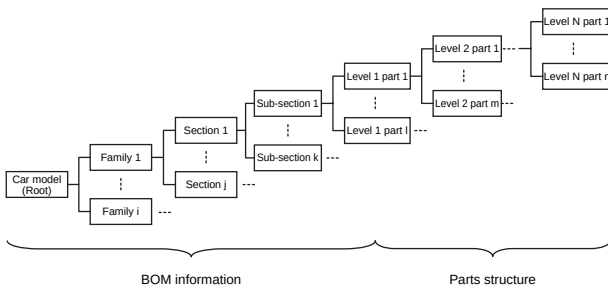


Fig. 1 Car structure in BOM system

of the range of models for which DPM could be constructed.

By contrast, in the system discussed in this paper, parts structure data is stored as V5 data called CATProduct (assembly structure-preserving file) data, and parts structure data and parts positioning data at Level 2 and below is thus not managed in the PDM system as a tree structure (Fig. 3).

Below, this tree structure will be called Work Package Mode.

The use of Work Package Mode helps to control the increase in link data when the history of design changes for variations and parts structure increases, and helps to ensure that system responsiveness is maintained when filtering processing is applied.

3.2. Coordination with BOM System Data in Units of Days

Using the former system, the latest parts structure data for a full car was recorded in units of weeks according to the model name and data instructions for the variations.

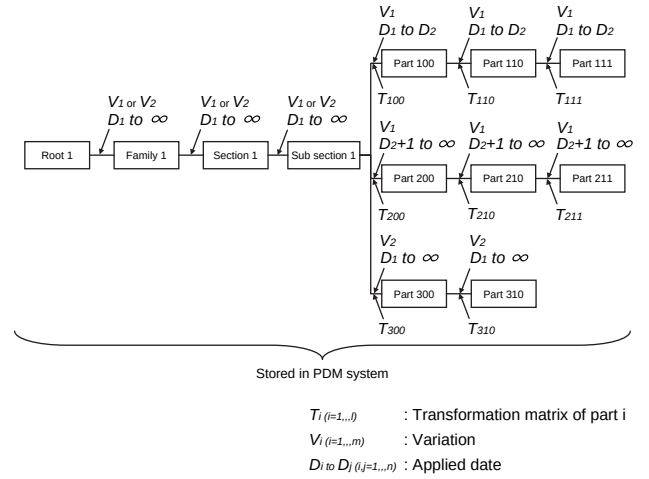


Fig. 2 Structure tree definition of Exploded Mode

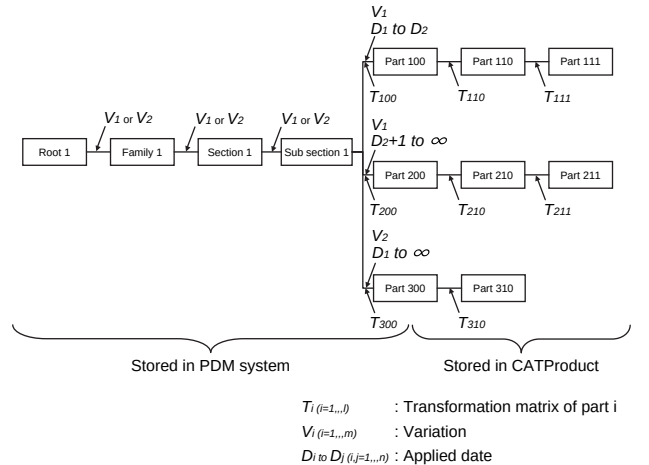


Fig. 3 Structure tree definition of Work Package Mode

Because of this, an increase in the number of models and variations for which DPM were constructed would result in an increase in time for output from the BOM system and time for recording in the DPM construction system. In addition, because updates were conducted in units of weeks, inconsistencies occurred with the details of design changes that were processed on a daily basis in the BOM system, and this became an issue impeding the expansion of the application of DPM.

Accordingly, in the new system, data concerning models and variations for which DPM will be constructed is recorded in advance in the BOM system, and is output to external files in units of design changes of the parts applied in the recorded variations (Fig. 4).

This has helped to reduce the time for extraction of BOM data processed by the BOM system.

In addition, the daily recording of the external files in the system has reduced the time for recording, and has helped to prevent inconsistencies with the BOM system data.

3.3. Changes to the PDM System

In the former system, DPM were constructed with VPM operating in a UNIX environment employed for 3D data formulated using V4. The introduction and maintenance of UNIX machines entailed high costs, and this was a further issue impeding the expansion of the system by means of increasing the number of models and variations for which DPM were constructed.

With the transition of the CAD system from V4 to V5, the new system adopted ENOVIA V5 VPM ("LCA" below) in order to obtain the following advantages:

- (1) High level of compatibility with V5 (Fig. 5);
- (2) Ease of access to parts structure data and 3D data from V5 (Fig. 6); and
- (3) Low-cost and high-speed processing using Windows machines.

This helped to enable the reduction of modeling time following recording of parts structure data.

3.4. Realization of Scalability via Distributed Processing

When the new system conducted distributed processing, errors sometimes occurred in the various

processing steps. A function helping to enable the system to easily detect processing errors and respond rapidly was therefore necessary for system operation. A distributed processing function developed in-house for application in another system was used in the new system to help satisfy these conditions.

Figure 7 shows an overview of the configuration of the job control system.

Data from the DPM construction server (the submit machine) is recorded as a job in the job queue (database).

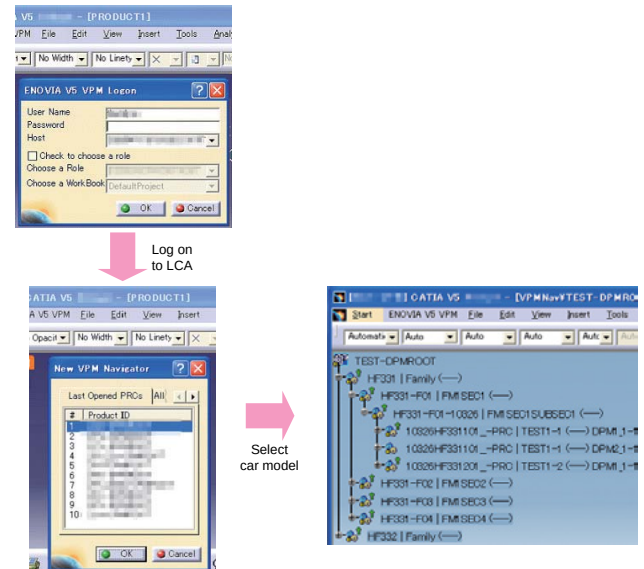


Fig. 5 Operation to access to structure tree

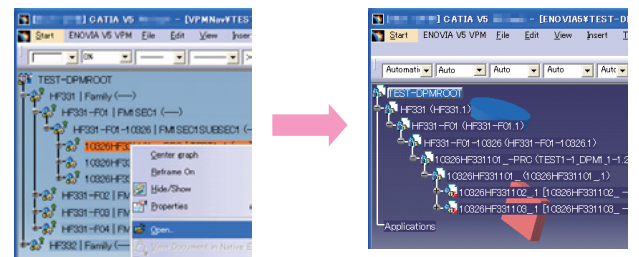


Fig. 6 Operation to access 3D data from structure tree

	Date						
	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.
Previous system							
Drawing issues	✓	✓	✓	✓	✓		
Structure lists							
: Parts structure of full car							
	Date						
	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.
New system							
Drawing issues	✓	✓	✓	✓	✓		
Structure lists							
: Parts structure of 1 drawing issue							

Fig. 4 Timing of drawing issue and structure output

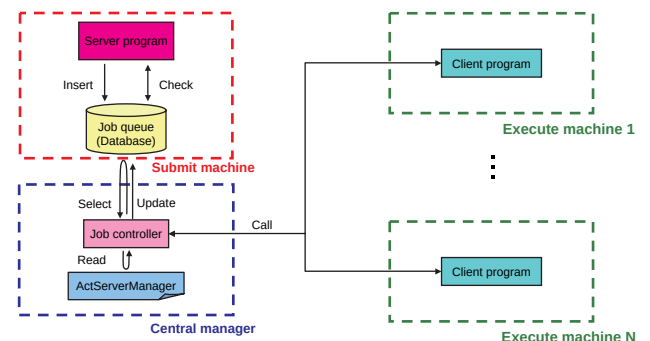


Fig. 7 System configuration of job control system

The job controller periodically monitors the database, and allocates the job to the CATIA processing machines (the execute machines). In the CATIA processing machines to which the job has been allocated, the data is written in a view format in the processing management file (the ACT server manager); the number of processing treatments that can be conducted simultaneously can be set here. The processing management file can be modified even during job allocation, and scalability can be realized via the number of processing treatments.

In addition, the status of the job that has been executed is reflected in the database, and when an error occurs, processing can easily be conducted again by modifying the status. This has helped to increase the efficiency of the operation of the DPM construction system.

4. Data Transfer from Former System

During the development of the new system, it was vital to transfer data in order to effectively utilize the DPM data resources of the former system. Data for models that would be usable in the new system was selected for transfer. Table 1 shows the numbers of data transferred.

Based on these data numbers and the period for which they would be used in the new system, data transfer was conducted with the following service assurances set for the departments that would utilize the data in-house:

- (1) Conversion of Exploded Mode into Work Package Mode, with assurance of no discrepancies in the fitting positions of each part in the global coordinate system;
- (2) Conversion of V4 data to V5 data with assurance of accuracy of three-dimensional form; and
- (3) Completion of data transfer per model and suspension of service within the shortest period (two weeks).

4.1. Conversion of Data from VPM to LCA

To allow coordination with external systems, the data formulated in the former system was output in the EXPRESS data modeling language specified by ISO 10303-11 ("STEP Part 11" below), as external files expressed using the exchange structure format specified in ISO 10303-21 ("STEP Part 21" below)⁽³⁾.

However, the readability of the STEP format is low: not only is there a high volume of standards documents, but the standards are dispersed, and if they are not reconstituted, understanding them represents a challenge. In addition, because the files themselves were expressed using VPM data management information, it became challenging to grasp the data in-house as parts and vehicle configuration data.

It was therefore determined that for future DPM data conversion, the STEP Part 21 format would be replaced by the XML format, based on consideration of the following points:

- (1) Increased in-house usability;
- (2) Increased readability when data is converted; and

Table 1 Amount of data convert

Item	Number of models	Number of variations	Number of V4 data	Number of V5 data	Total number of V4/V5 data
Total	24	69	31888	14750	46638

- (3) Reduction of system development costs by using widely available XML tools.

The conversion from Exploded Mode to Work Package Mode was conducted simultaneously. The process was conducted such that the coordinate transformation matrices for the global coordinate structure of the lead parts for each product structure were also written in the XML file, helping to enable their positions in the full vehicle to be recovered from the XML file.

In addition, the XML was made effective in the specific namespace of the new system, and development was conducted to help enable it to also be used as an input file format. At the same time, the system was configured to help enable DPM parts structure data formulated in the new system to be output in XML in the same format. This helped to enable the following:

- (1) Shared use of data for other models when DPM are being newly constructed;
- (2) Copying of position data when parts numbers are switched from prototype form to mass-production form; and
- (3) Provision of data to other systems.

4.2. Conversion from Exploded Mode to Work Package Mode

As discussed above, in Exploded Mode, position data for each part in the parts structure data is expressed as a coordinate transformation matrix in relation to the local coordinate system of that part's parent part. Because of this, when the coordinates of a part in the global coordinate system are calculated, a product of the coordinate transformation matrices for all the higher levels in relation to the part in question is necessary (Fig. 8).

By contrast, in the Work Package Mode employed in the new system, parts at a lower structural level (assembly parts) are expressed using CATProduct. The positions of 3D data included in the CATProduct are expressed as coordinate transformation matrices from the parent

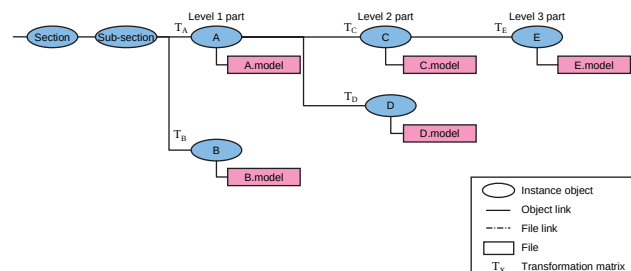


Fig. 8 Position matrices of Exploded Mode

CATProduct, and stored in CATProduct (Fig. 9).

This helps to enable the expression of position data for assembly parts as local coordinate systems, and when assembly parts are utilized in another model, they can be arranged without being affected by the specific position data for that model.

When the unique XML data for this system is formulated as discussed in the preceding section, coordinate transformation matrices that provide position data for each part are calculated, and coordinate transformation is conducted from the global coordinate system to local coordinate systems. The use of the XML developed for the system has helped to enable automatic formulation of CATProduct data that expresses the parts structure, and offered the ability to set relative positions within the assembly.

4.3. Assurance of Form when Converting to V5

The format for storing 3D data in V5 differs in part from that used in V4, and it is therefore necessary to check for any discrepancies in form after conversion. A three-dimensional form error detection system that was developed in-house was therefore linked to the system and the three-dimensional data following conversion was checked to help enable study of differences in form occurring when V4 data formulated was converted to V5. This process of detection of differences in form was conducted in the following two stages for CAD data before and after conversion:

- (1) Comparison of solid numbers, surface numbers, volumes, centers of gravity, and surface areas; and
- (2) Comparison of surfaces and edges.

However, it was decided that in order to reduce processing time during data transfer, (2) would only be conducted when a discrepancy had been detected by (1).

The results of these form comparisons were as follows:

- (1) No discrepancies of form were observed for approximately 90% of the models for which three-dimensional data formulated in V4 was transferred;
- (2) In the case of models for which form discrepancies were observed, the three-dimensional models were manually corrected; and
- (3) In the case of data for which the process of comparison was not conducted correctly, forms were compared in V5.

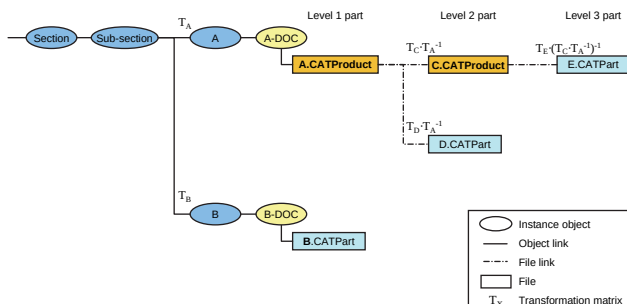


Fig. 9 Position matrices of Work Package Mode

As a result, it was possible to convert all of the 31888 pieces of V4 data shown in Table 1 to V5 data.

5. Effects of the New System

- (1) The time from a drawing issue to the completion of the DPM has been reduced by four days from a maximum of 10 days to six days.
- (2) Position data in the global coordinate system from the output product configuration data can be used in the focus model or in other models, and the time for setting positions has been reduced by approximately five minutes per Level 1 part.
- (3) Models can be constructed on Windows machines.
- (4) The ability to extract changes in units of design modifications in coordination with the BOM system has reduced the man-hours necessary for extraction of changes.

6. Conclusion

The development of the system discussed above produced the following results:

- (1) The reduction of tree data managed in the PDM system in comparison to the former system has helped to enable the models and variations for which DPM are constructed to be increased;
- (2) Data can be coordinated with BOM system data in units of days, helping to enable data from drawing issues to be formulated as a DPM in the shortest possible time-frame;
- (3) The use of V5 as the system for the construction of DPM has helped to enable DPM to be constructed in Windows environments; and
- (4) The introduction of a distributed processing function has helped to realize scalability of the DPM system.

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