INTERNATIONAL DESIGN CONFERENCE - DESIGN 2002
Dubrovnik, May 14 - 17, 2002.

TRANSPARENCY IN DOCUMENTS AND ACTIVITIES IN PRODUCT AND PROCESS DEVELOPMENT AT AUTOMOTIVE SUPPLIERS

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Keywords: development process, automotive industry, information overview

1. Introduction

Before an EDM/PDM-system can be implemented within a company, the internal processes of product development and the information used and created within these processes should be organised well. To enable this organisation, one should be able to see the bottlenecks and thereto the product and process development and the documents handled herein should be made transparent. [See also Vajna e.a., 2001; Clarkson e.a., 2001]. In literature, very little is found on details about the information handled within product and process development of industrial companies. To gain insight of this kind of information, a research project was started in 1992.
In this research, the development processes of three automotive suppliers are analyzed and documented in three representations. These representations are formatted according to a generic representation scheme that is developed specifically for these case studies. In these representations, organization, documents, and activities of product and process development are mapped in relation to each other. These representations are compared and based on the similarities found in these comparisons a so-called induced model of product and process development is created.
In this induced model, the knowledge and experience of the three automotive suppliers is bundled. The induced model can be used on the one side as an initial expectation when charting an as-is situation of a company and on the other side the induced model is useful as a resource of ideas when creating a to-be situation of a development trajectory for a company.
The research is executed with help of an industrial sounding board in which representatives of the three companies were included.
In this paper, the format of the representations and the induced model will be shortly explained. The creation of the induced model and the corresponding guidelines will be described, and finally the resulting induced model will be presented.

2. Generic representation scheme for product and process development

At first, a method and instruments are developed which enable the consistent representation of product and process development together with relevant information in a database and in clearly structured diagrams. These instruments constitute of 1) a generic representation scheme defining the format of company-specific representations, 2) a software tool to facilitate the application of the representation scheme, and 3) a method for the application of the scheme. Using this method, the product and process development and its corresponding information are captured systematically and result in a consistent representation.
The representation scheme defines the format for the company specific chartings and consists of three

aggregates of object classes, called *main object classes*, which are: Subject (to register the organization); Activity (for the processes) and Information. These three main object classes represent who (subject) does (activity) what and with which information. In figure 1 the main object classes and the relationships between and within these main object classes are represented.

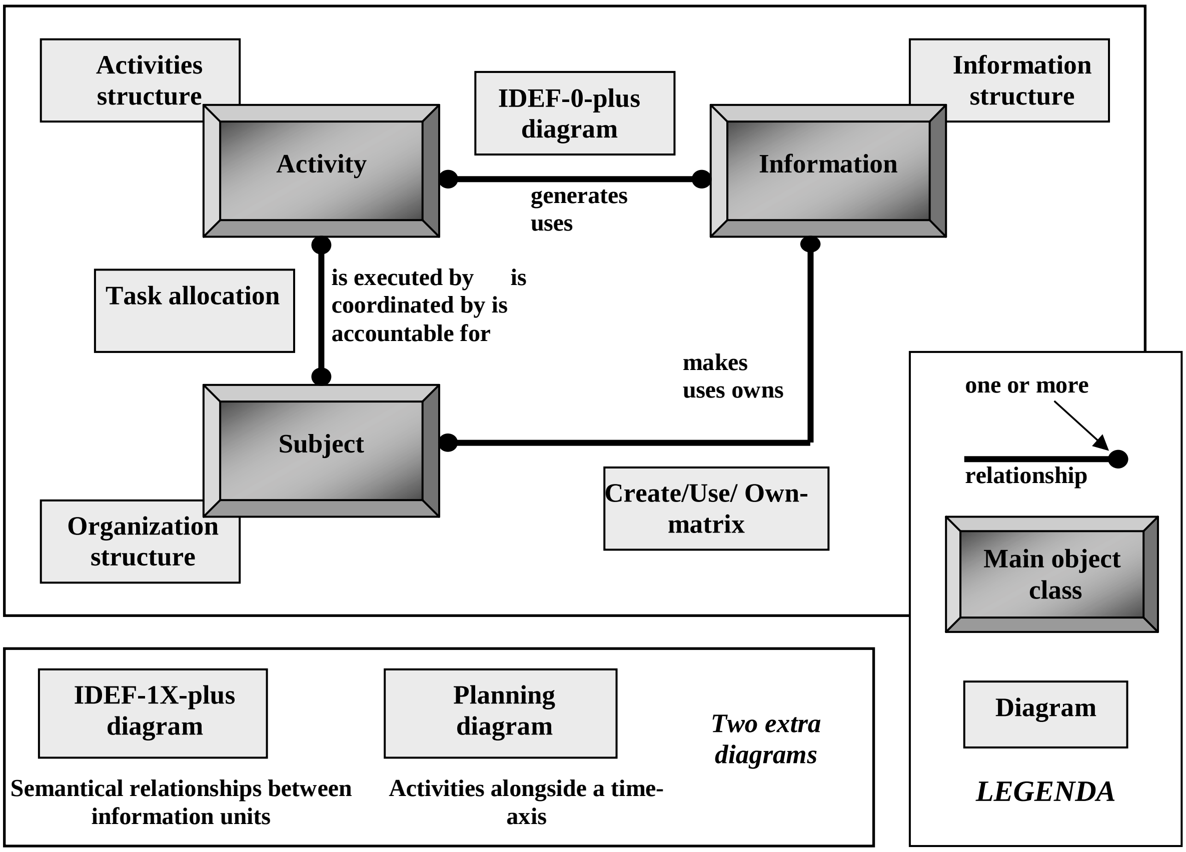

Figure 1. Generic Representation Scheme

The three coherent main object classes together make up a three-dimensional model of a database in which the three main object classes are the three dimensions. However, for a good overview of the database, two-dimensional pictures of the model are required. Therefore, eight diagrams are defined. Three of which represent the relationships within the main object classes (these are the diagrams named activity structure, information structure and organization structure). Three other diagrams represent the relationships between the main object classes (which are: IDEF-0-plus diagram, task allocation matrix and create/use/own-matrix). Furthermore, there is one diagram extra especially for the main object class *Information,* representing the semantic relationships within this class. Finally, there is one diagram that represents the activities in the proper order and frequency alongside a time-axis.

Instances of the object classes contain all information required to automatically generate six of the eight diagrams that represent the development process. That is why a software tool is developed that facilitates and accelerates the application of the generic representation scheme. The name of this tool is GDPT, which stands for Graphical Database Presentation Tool. In fact, the tool generates pictures from the contents of the database.

By using a representation scheme-editor small adjustments to the representation scheme can be made, which makes the representation scheme somewhat flexible. This is useful because not every company can be forced into exactly the same structure. This flexibility mentioned could be made available in GDPT because it does not affect the basic structure of the three main object classes. So the same diagrams can still be applied.

3. Guidelines for the creation of the induced model of a development process

3.1 Introduction

After the development of the instruments, the three companies are analyzed leading to three company-specific chartings represented according to the representation scheme developed. These three descriptions are compared with each other and with current theories. In the three cases, sufficient similarities were found for the creation of a more generic so-called *induced model*. In this section the guidelines that are used in creating the induced model, based on the case descriptions, are described and the choices made are explained.

3.2 The detail level used in the induced model

Each main object class of the representation scheme is refined into object classes. These object classes represent different levels of detail. For example, the main object class *Activity* is specialized top-down into the following object classes: Analysis area; Subdivision of analysis area; Procedure; Task; Activities & Decisions (see figure 2). This subdivision of activities into smaller ones is the base of every methodology [Ehrlenspiel, 1999]. For the induced model, choices are made to introduce one or more levels per main object class. These choices are made pragmatically, balancing between too abstract on the one hand which would make the induced model not very informative, and too detailed on the other hand which would make the induced model too company-specific or too large and therewith it would not provide enough overview. The levels used are shown in white boxes in fig. 2.

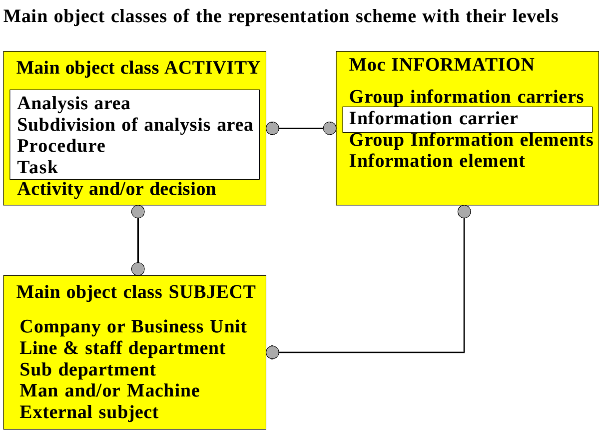

Figure 2. The levels per *Main object class*

With regard to the main object class *Activity*, it is decided that the level of *Tasks* is the lowest (most detailed) level to be represented. The levels higher than *Tasks* are hierarchical related to the level of *Tasks* and they will be represented as well. Therewith a structured overview of the activities in the induced model can be given: the *activity structure*. Figure 3 illustrates the result at the detail level of the object class named *Subdivision of Analysis Area*.

With regard to the main object class *Information*, the induced model is created at the level of *Information carriers*. This level is not about the device or whatever the information is put on (paper, floppies, physical models, etc.) but it is about the contents of information carriers. If a lower level (a more detailed one) would have been chosen (that is the level of *Group information elements*) than the number of entities (about 1000) would be too much to achieve an overview. Nevertheless, the number of Information carriers is also still high, namely 200.

For the main object class *Subject*, there are too little similarities found between the three cases with regard to the organization. Furthermore, the organization schemes appeared to be unstable during the research due to the many reorganizations within the companies. That is why the organization scheme is excluded from the induced model. In [Vroom, 2001] one can find the examples of the cases for this main object class.

3.3 The creation of the induced model

An activity structure is generated based on comparisons of the activity structures of the cases. At the level of *Subdivision of analysis area*, also other models - from literature - are compared and processed [Roozenburg e.a., 1998], [Blessing, 1994], [Eekels and Poelman, 1998], [Haag e.a., 1996], [Vroom, 2001]. Next, the internal consistency of the activity structure is checked. Then the information carriers belonging to the activities are determined. The resulting list of information carriers is compared with the lists of information carriers of the cases and the resulting list is adjusted based on these comparisons. The internal consistency of the list of information carriers is also checked. Finally, the activity structure and the list of information carriers of the induced model is checked in relation to each other. This way the induced model is build up both bottom-up and top-down.
Two approaches for the creation of an activity structure are identified. One approach is to group as many types of activities as possible. For example, all evaluations are grouped together and so on. The other approach is to try to represent the proper sequence of the activities. This latest approach was the most favorable one for the companies and the sounding board, and is therefore chosen for the induced model. In a somewhat chronological activity structure, phases are recognizable, although of course they are not executed fully in sequence but partly parallel.

3.4 Choices for the information carriers in the induced model

The following guidelines are employed to make decisions and choices for the information carriers in the induced model:

- as little information carriers as possible
- the information carriers together should contain all required information for the product and process development
- the development process should not be complicated by too much clustering of information

On behalf of selections from the information carriers of the three cases for the induced model, also so-called cross sections are made. Thereto the information carriers which describe a certain aspect are put together. These aspects are for example the quality checks, the costs or the production process. This was helpful for choosing the carriers and covering all aspects in the most efficient way.

4. Induced model results: activity structure & list of information carriers

In this paragraph the activity structure and the list of information carriers of the induced model are presented. As mentioned before, the Analysis area A-0: Product and Process Development in the induced model is subdivided into 13 so-called Subdivisions of analysis, as is represented in figure 3.

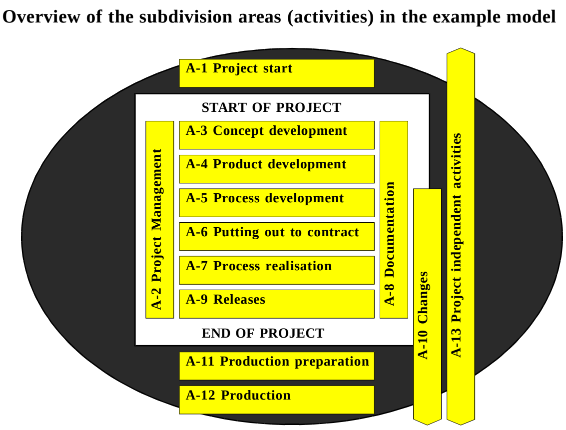

Figure 3. Overview of the activities in the induced model

These Subdivisions of Analysis (A-1 to A-13) are further elaborated down to the level of Tasks. An example of the results of this elaboration is presented at the next page.

A-3: Concept Development

- **A-3.1: Develop product concept**
  - Elaborate List of requirements
  - Develop partial solutions for technical functions
  - Develop global total solutions
  - Select and lay down product concept (e.g. drawings, initial test manual)
  - Lay down preliminary Bill of materials
- **A-3.2: Assess product concept**
  - Simulate solutions
  - Describe product concept in expected results (specifications)
  - Assess product concept (using List of requirements)
- **A-3.3: Review product concept**
  - Determine conditions and requirements for further development
  - Go/no go decision about the continuation of the project

The information list of the induced model is divided into four types of information, which are (A) library information, (B) product and process descriptions, (C) design rationale and (D) project management information. These characterizations will be described further.

A: Library information or available knowledge and documentation. This type of information concerns all information that is consulted during the development processes for product and process designs as regards content. This type of information also includes the knowledge available at colleagues and experts and in company databases. The company function belonging to this type is the technical documentation center or library. Although this kind of information influences the designs, it is not specific for one product or process design and is therefore called project-independent.

B: Product and process descriptions. This is the information that describes the product and process designs in the several stages of the product creation process, starting with an initial description of the product through a list of requirements, sketches, models, drawings, samples, etceteras to the technical product documentation. In other words the history of coming into existence of the product and production process is laid down in the so-called product and process descriptions. This kind of information belongs specific to a product and process design and results in the technical product documentation. In the technical product documentation the complete definition of the product is documented. This type of information is project specific.

C: Design rationale. This is the type of information that leads to a design decision. It is the reasoning behind a design. For instance, the calculation of a material thickness is an argument for a design decision and therewith part of the design rationale, while the result of this calculation i.e. the resulting material thickness is part of the product description. The archive of arguments for design decisions is usually not explicitly present although it is the ground for maintenance and repair instructions. It concerns information that often is stored "in the heads" of engineers and designers or dispersed in drawers and desks. Especially when information and knowledge of existing designs have to be used for new designs, this type of information is of essential importance. When the reasoning behind certain design decisions is known, the developers of following development projects are protected from changing parts wrongly. Type C is a project specific type of information.

D: Project management information. Project management information is the information that has impact on the project itself. It concerns information made by the project management itself during the direction and monitoring of the project. Examples are capacity planning, progress monitoring, and policy guarding. The management of the organization and the financial management are important users of this type of information. This kind of information is project specific.

In [Vroom, 1996] it is argued that the four types of information described here together form the engineering data, which are the data that are of relevance for the engineering and development department of a company. Whilst information about product and process descriptions (type B and more) which is also used in other business functions such as Marketing, Production, etceteras is called product data and is subject for product data management. Product data and engineering data do overlap each other but both have their own domain as well. See figure 4.

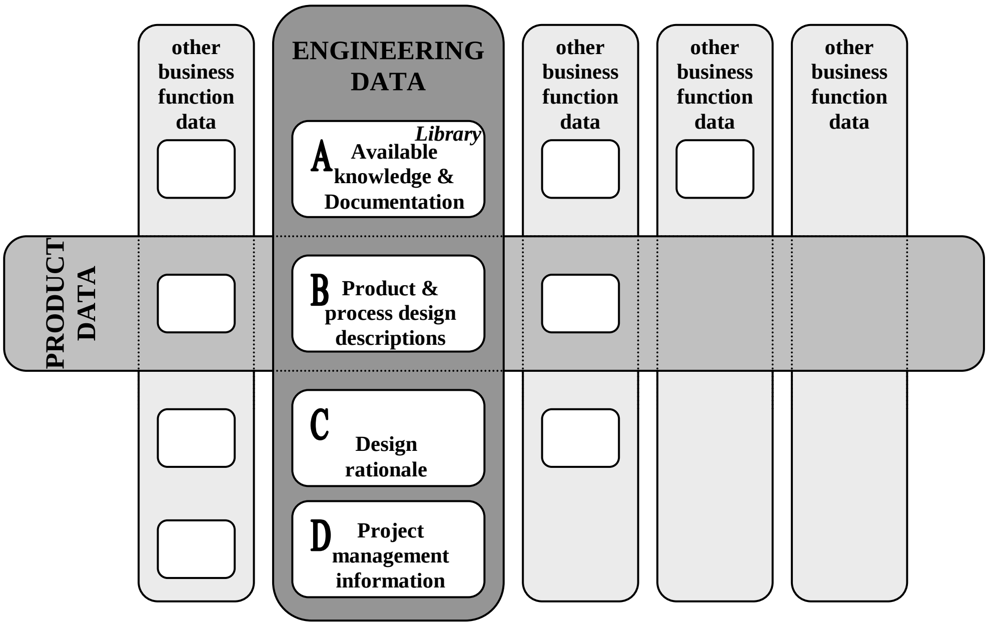

Figure 4. Domains of Engineering and Product Data

The list of information carriers is presented below. The I-numbering in this list refers to [Vroom, 2001] in which more background information on the documents can be found.

Type A: Available knowledge and documentation

Characteristic financial values (I-21)
Checklist production part (I-99)
Competing designs (I-95)
Customer specifications (I-5)
Drawing standards (I-68)
General company standards (I-193)
General legal information (I-37)
Info from knowledge databases (e.g. calculation models, former design solutions) (I-36)
Information on competing designs (I-39)
Information on patents (I-59)
(Insight into) knowledge of team, comp., env'mnt (I-17)
List of standard conditions & definit'ns Purchase (I-191)
Machine data (I-109)
Market information (I-1)
Market strategy and Marketing plan (I-3)
Overv. of relevant available production processes (I-18)
Product information from suppliers (I-67)
Req'mnts & standards from certificat'n committees (I-38)
Sales forecast long term (market potential &shares) (I-56)
Technical documents (literature, int. standards, ..) (I-66)
Tool standards (I-192)

Type B: Product and process design descriptions

Action plan (I-9)
Approved external parts (I-142)
A-sample (I-89)
A-sample parts (I-87)
Assembly line (I-153)
Assembly process description (I-138)
Bill of materials for product concept (I-46)
Bill of materials for product design *frozen* (I-122)
Bill of materials product design (I-80)
B-sample (I-112)
B-sample parts (I-111)
Calculated realization costs for tools (I-146)
Calculation of costing in advance (I-22)
Change decision (I-182)
Complete set of info of product under production (I-179)
Concept assembly process description (I-108)
Concept process parts production description (I-102)
Concept tool descriptions (e.g. moulds) (I-103)
Control plan *(initial/updated)* (I-114)
Costing collect form (I-178)
C-sample (I-154)
C-sample parts (I-149)
Customer requirements (I-4)
Definitive calculation of costing (I-177)
Descr. of product concept (incl. detail sketches) (I-43)
Design notes (on behalf of patent application) (I-71)
Drawings of product concept (I-44)
Envelope drawing product design (I-77)
Exploded view drawing product design (I-78)
External production parts (I-189)
External realized (parts of) parts (I-141)
Global overall solutions of design problem (I-41)
(Informal) development order (I-6)
Information from (potential) customer (I-2)
Information regarding the development problem (I-7)
Initial ideas for solutions of the design problem (I-14)
Initial sample inspection report (ISIR) (I-173)
Initial samples (I-170)
Initiation patent request (patent disclosures) (I-61)
Internal production parts (I-188)
List of requirements *(initial/elaborated)* (I-11)
Offer (quotation) (I-172)
Operating software for tools (I-144)
Order for developing tools (incl. meas. & check.) (I-125)
Order for developing assembly process (I-124)
Order for developing process internal parts (I-123)
Order for external production of sample parts (I-83)
Order for making an early trial model (I-47)
Order for making A-sample (I-82)
Order for making B-sample (I-106)
Order for making C-sample parts (I-147)
Order for producing external parts (I-126)
Order for standard components (screws etceteras) (I-84)
Order for trial production (I-134)