MODELING DESIGN ACTIVITY IN AUTOMOBILE INDUSTRY

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Abstract: Designing and consequent assembly of a new vehicle is a complex process as it requires close coordination and inputs from a number of disciplines in developing a number of systems and sub-systems in the vehicle that should fit within the confined vehicle space, function and provide the customers an acceptable combination of all relevant vehicle attributes. Understanding how these processes interact and how they are aligned with other while they should support the tasks involved in the conception of a new vehicle at a minimum time and cost. The first step to achieve this goal is the Modeling Business Process using UML (industry standard language)

Keywords: Automobile Design, Modeling; UML-Profile.

1. INTRODUCTION

The Automotive industry is changing drastically. Many companies are re-organizing, reengineering, downsizing, and above all changing their approach to engineering vehicles. The reasons for these changes are numerous; increased competition, new market requirements, greater customer focus, vastly improved information technology, outdated business practices, etc. To be successful in the coming century the company must challenge and beat the intensifying competition; understand, exceed and drive the new markets; surpass heightened customer expectations; install and fully utilize the most advanced information technology; replace the old business practices with new aggressive global strategies; and, finally, do all this profitably. Automotive companies are focusing on the processes of delivering a new or updated high quality vehicle to the market faster and cheaper. To assure this goal, modeling process through an appropriate language is mandatory. UML has emerged as the software industry's dominant language and is already an Object Management Group (OMG) standard. It represents a collection of best engineering practices that have been proved successful in the modeling of large and complex systems. OMG is proposing the UML specification for international standardization for information technology [Kohyn, 2001]. Wide recognition and acceptance, which typically enlarge the market for products based on it, will be the major benefits. Therefore specific subjects (e.g. vehicle design process) require making UML models more specific and thus more precise. This in turn can be done by using stereotypes (since they are an extension mechanism inherent in second version of UML) as a means of adding necessary information to existing model elements.

2. UML Profile for New Vehicle Design (VDML)

The aim of this new profile created specific for new vehicle process development is to capture the specific concepts involved in this activity process and provide an appropriate notation. Based on UML we will propose a meta-model for IR, based on a stereotype. New vehicle design main stereotype are: (1) «Activities», which are performed by actors and operated over resources and information; (2) «Actors», that is someone (a human actor) or something (an automated actor, such as an information system or a production machine) that can perform the actions required by an activity; Actors belongs to organization units (departments) (3) «Resource» is the input and output of an activity representing things such as materials, information system operated by human actors; (4) «Information» is also input/output of activity ;(5) «Goal» represents a measurable state that the organization intends to achieved; (6) «Measure» and; (7) «Alert» The stereotype «goal» describes the specific intension of a business process and is quantified by at least one «Measure». The «Goal» extends the metaclass Activity, meaning that a «Process Goal» is described at activity level. The stereotype «Measure» can be classified and implemented as «Quality», «Cost» and «Cycle Time». This means that the stereotype «Measure» can be described in three different ways. It is the modeler's role to choose the most suitable way to best describe a measure for a certain purpose, a user or user group. Moreover, the stereotype «Measure» is responsible for the concrete quantification of different goals as well as for measuring the performance of a business process for its execution. Its tagged values and operations are necessary to compute e.g. average values like the total and monthly average cost of a certain process. The performance measures of «Quality» and «Cost» are in contrast to the measures of the «Cycle Time» often more focused on the type level of a process, as the required data is often not available on instance level. The stereotype «Cycle Time» presents a time based measure and defines the duration a activity, or part of it requires from the beginning until the end. The stereotype «Cycle Time» can be specialized as «Working Time» or «Waiting Time». «Working Time» presents the actual time a business process instance is being executed by a role. «Waiting Time» shows the time limit the process instance is allowed to delay further processing. Moreover, «Cycle Time» has two tagged values, for representing the target value and the actual value of the process duration or a part of it which is computed by an operation of the stereotype. The purpose of these stereotypes is besides showing the role that performs certain actions, to make the «Organization» visible that is triggered by the stereotype «Alert», if an action or a group of actions is not executed within its performance measures. An «Alert» belongs to exactly one «Measure» as well as to one element of the «Organization», and has one tagged value to show on instance level if an alert is caused or not. To simplify the study the process of new vehicle design we propose two views: (1) Object Model View performed in a UML use case diagram, where we capture relations among different actors (e.g. hierarchical information in a company, responsibly relations between different actors, skills and competences); and (2) Role Model view, performed in a UML activity diagram, where we capture all process and information transformation These views act like the different views in an architectural project of a house, simplifies the process by dividing the problem in smaller pieces. The views are chosen between a compromise of simplicity (more views) and complexity (few views). Modeling this process activity requires capturing the essential concepts that are involved in the process. Examples of concepts are activities that use resources and information and operated by actors in order to achieve a goal.

3. Modeling Design Activity

We will modeling this activity based on two views: (1) object model view and (2) activity diagram view.

3.1 Model Object View

Human resource and skill management has become an object of growing interest as their importance. Skill management intends to give competitive advantages in organization by taking into account human resources as strategic assets and integrating then in the business process goals. This perspective already has been studied in knowledge management studies [Woodruffe 93,Stone 95, Hamel 90]. Skill management plays an important role in different organizational activities, such as: (1) personnel recruitment; (2) expert finding; (3) project management; (4) alerts for missing goals; and (5) personnel development.

In this view we intend to capture relations among actors which participate on the activity process, capture in a contextualizing way the communication between actors, display actors responsibilities and skills. In the design activity of new products, the main actors, illustrated in Figure 1 are: (1) CAD Eng demonstrates the ability to interpret and develop a model from a 2D picture or instructions, such as Design Objectives into a 3D model using appropriate techniques to ensure a feasible, proportionally balanced model which meets the design requirements, work with little or no direction to develop a surface displaying an appreciation of shapes, proportions and perception of the final outcome of the 3D model, develop both intricate and surface model, surfaces to within 0.2mm of engineering feasibility data, within the required time frame perform feasibility and packaging studies and verifies solutions to be in compliance with regulations; (2) CAS Eng produces sketches to invoke the feeling of acceleration or tension, sharpness or softness according emotional and creative passions and the market segment of a car. Defines stylistic properties and then creates CAS tools that can capture and produce emotions. The aesthetic shape properties produced, will concur to generate time, energy, and money throughout the design process: from creating and modifying models, to the disconnection in concurrent aesthetic and engineering design, to the broken feedback loop from downstream design/engineering processes; (3) CAE Eng is responsible for predict product performance, drive design, and minimize cost and weight. CAE is also involved in most of the customer functional attributes: durability, NVH (Noise Vibration and Harshness), safety, vehicle dynamics, thermal management, aerodynamics, fuel economy and performance, package, weight, electrical systems and electronics; (4) Testing and Validation Eng are responsible, within the Product Development Teams, to identify, perform, and follow up all the tests and validations required to a certain area of the vehicle. Their feed back is essential to the approval of the work produced by the engineers and can originate severe corrections and changes to their work; (5) Product Development Team has the responsibility of development and integration of a certain area of the vehicle as well as its compatibility with the adjacent development teams. For example, electronic and electric development team is responsible for the integration of wiring looms and modules and respective functions as well as the harmonious integration of all the switches and commands in coordination with the interior development team. These teams have a pre defined speaker that reports to the product manager and interacts with the other product development teams; (6) Product Manager has the overview of all product development related activities progress and controls the achievement of the various milestones. Identifies, and submits to the project manager approval, special plans for timing achievement if required based on the recommendations of the product development teams; (7) Project Manager has the overall control of the project for timing and costs targets achievement, regarding product development, purchasing, quality and manufacturing activities. Analysis critical situations coming from the various teams and submits recovery plans for approval of the Board of Directors; (8) Market Researcher is responsible to collect information about clients' needs, future tendencies and features for a new car. Provide data that is used to support critical technical and financial decisions during all the product life cycle; (9) Reverse Eng is responsible for the production of electronic 3D solid product models from captured surface geometry data for use in

CAD/CAM/CAE/CAV environments using Reverse Engineering techniques and processes; (10) Purchasing Team, is responsible to find and negotiate the price with supplier for all the new parts identified in a new product; (11) Manufacturing Team, is responsible to specify and follow up with equipment suppliers the development and installation of all the machinery necessary to produce the defined product. These last two actors have indirect participation through product development teams.

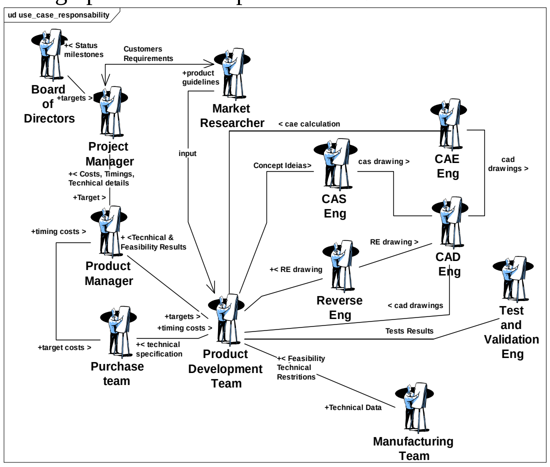

Figure 1: Use case view of process design of a new vehicle.

3.2 Activity Diagram View

The main activities divided by organizational units, illustrated in Figure 2, involved in new car design process are organized by major areas, such as: Coordination, Technical, Product Integration Testing and Validation and Product Evaluation. Our intention on this paper is to describe this main activities and sub-activities to provide a high level vision and introduce improvements, common notation and add some agility to the process itself. A global overview of the design activity of new product is proposed.

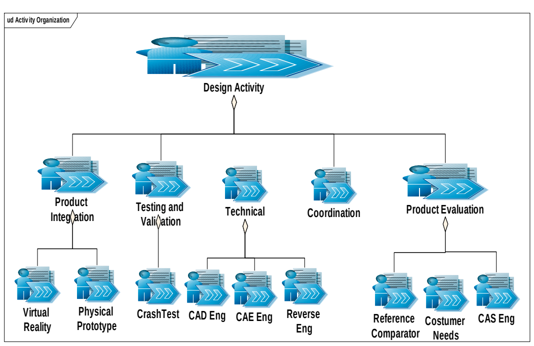

Figure 2: Main activities organization.

The main activities divided by organizational units, illustrated in Figure 2, involved in new car design process are organized by major areas, such as: **Coordination**, **Technical**, **Product Integration Testing and Validation** and **Product Evaluation**. Our intention on this paper is to describe this main activities and sub-activities to provide a high level vision and introduce improvements, common notation and add some agility to the process itself. For better understanding of how the process flows, on Figure 3 we highlight the main activities temporal sequence. A detailed activity view is proposed of each activity.

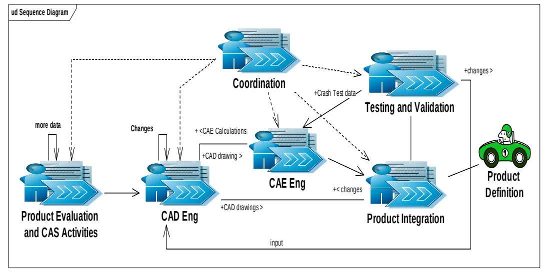

Figure 3: Main activities temporal sequence.

Product evaluation. We begin with the description of **Product Evaluation** and **CAS Eng** activities. This activity is illustrated in Figure 4 and congregates information from both Reference Comparator and Costumer Needs activities. Defines the guidelines for the desired final product. This activity provides high level information which will be used by top management level to decide to go ahead or not with the development of a new vehicle. The **goal** of this activity is the **Guidelines (Market Assumptions),** that can be: price, car volume and product guidelines like model, engine, weight, colours, powertrain and comfort. Main inputs of this activity are: (1) **Reference Comparator:** activity that studies the market for the specified model or picks similar characteristics from an internal database; (2) **Costumer Needs:** activity that studies the costumer needs (KANO tables) and expectations of the product performed through market studies and similar types of studies. **CAS Activity:** Produces the car sketch based on the guidelines proposed by the Product Evaluation activity and it is performed by CAS Eng. Main actors involved are: (1) **CAS Eng**, (2) **Market Researcher**, (3) **Board of Directors** and (4) **Product Manager** whose responsibilities are described in [Ferreira, 2007].

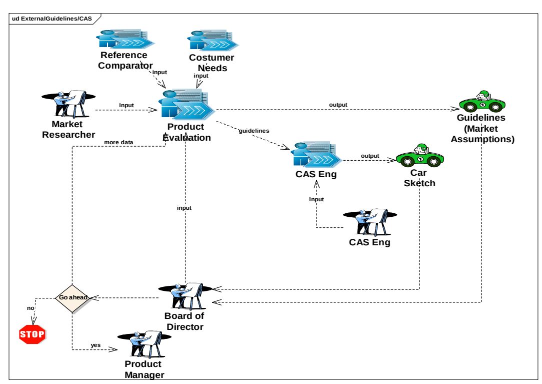

Figure 4: Product Evaluation and CAS Eng activities description.

CAD Activity: CAD Eng Activity is illustrated in Figure 5, defines the design of the vehicle paying special attention to ergonomic, functional and homologation requirements. Demonstrates the ability to interpret and develop a model from a 2D picture or instructions, such as design. As inputs this main activity has: (1) Guidelines: that is a specification list of the main characteristics given by Product Evaluation activity; (2) Benchmark & Teardown Database: database that contains information about benchmark products, which can be used as models; (3) Other Activities: This input makes part of the iteration development process and it may appear several times, as entry. Represents information given by other activities like the CAE activity, about reinforcements to approach and perform security rules in order to achieve a better protection to the passengers; (4) CAS Eng Activity: gives a general overview of final product shape and guidelines. The CAD activity is assisted by CAD software (e.g. Catia, Unigraphics, etc) as shown [Ferreira, 2007], ergonomics and homologation issues are automatic embedded in this software. This is an improvement achieved by this approach and illustrated in [Ferreira, 2007]. The goal of this activity is the car drawing part; Measurement: this process will check CAD activity output based on pre-defined targets such as: (1) time spent by the activity; (2) gaps on surface; (3) failed compliances; (4) general integration; (5) ergonomics and homologation issues; (6) center of gravity; (7) weight; (8) stability. Failures on these measurements can generate two types of alarms: (1) minor, small impact issues highlighted to Product Development Team and CAD Eng; (2) major, critical issues that can put the project in risk, highlighted to Product Development Teams and Product Manager. Main actors are: (1) Reverse Eng, (2) CAD Eng and (3) Product Development Team whose responsibilities are described in [Ferreira, 2007]

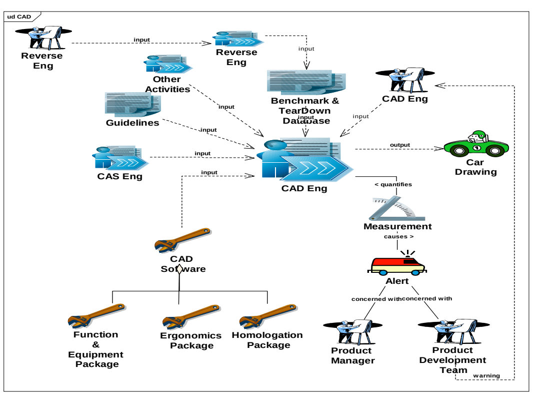

Figure 5: CAD Activity description.

CAE Eng Activity is illustrated in Figure 6. This activity studies the structure of the car and its security based on information given by CAD and Crash tests activities. The activity is assisted by specific software (e.g. Pamcrash, Nastran, Dyna, etc). Other issues analysed in this activity are: crash dynamics, chassis/suspension systems, vehicle dynamics, heat management, aerodynamics, climate control and human thermal comfort, etc. The main inputs are: (1) **CAD Eng Activity** and (2) **Virtual database Crash Test Activity:** tests the security of the vehicle creating different scenarios of crashing. **Measurement:** can be divided in time and security issues and this can be again divided in: (1) fulfilment of minors security regulation but are below the main security issue initially defined; (2) major, don't fulfil security regulations. The **goal** of this activity is mainly calculate the overall structural behaviour of the car an approach which should be the basis for any good design. Such global parameters as the static torsional and bending stiffness, the structural balance, the overall vehicle vibration modes and safety biomechanical responses, should be calculated in a sufficiently precise manner (relative statements). Main actors are: (1) **CAE Eng**, (2) **CAD Eng** and (3) **Product Manager** whose responsibilities are described in [Ferreira, 2007].

Reverse engineering activity can be defined as the process of analysing a subject system to: (1) identify the system's components and their interrelationships, and, (2) create representations of the system at higher levels of abstraction. Reverse engineering involves the extraction of design elements from an existing system, but it does not involve modifying the target system or generating new systems.

Product Integration, illustrated in Figure 7, describes the activity of integrating all the modules developed separately and achieve **Product Definition**, which completes the main goal of the design of a new vehicle. Product definition can be validated by digital and physical creation of the model. The digital validation is already performed by car manufacturers once it saves money and time in the whole development process and the results are reliable. Digital validation is done in the **Virtual Reality Activity** on a specific environment, virtual reality room, usually a cadwall projection system with dimensions around 7x3meters (allows scale 1:1) assisted by virtual reality software. Virtual reality software import CAD surface and creates a virtual model and scenario. **Prototype Activity** is performed by Workshop Eng, uses product definition and CAD data to construct with appropriate tools functional physical models that can be used for different purposes. The **goal** of both activities is to produce in a scale 1:1 a virtual and a physical model, respectively, of the vehicle and to verify the guideline requirements. The feedback of these two activities is essential to the approval of the work produced by the engineers and can originate severe corrections and changes to their work. **Measurements:** measures of the parameters identified in guidelines and its correspondences to the vehicle model. The main actors of these activities are: (1) **WorkShop Eng**, (2) **Virtual Reality Eng**, (3) **Market Researcher**, (4) **Product Manager**, (5) **Product Development Team,** (6) **Manufacturing Team**, (7) **CAD Eng** whose responsibilities are described in [Ferreira, 2007].

Testing and Validation activities give output to CAD and CAE activities. Testing activity checks results of CAE activity, crash test and the study of the results allows improvements and adjustments on the product definition.

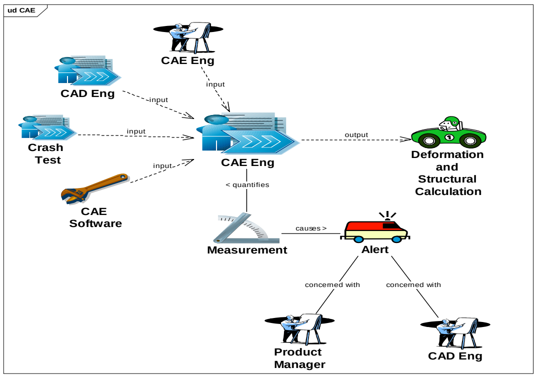

Figure 6: CAE Activity description.

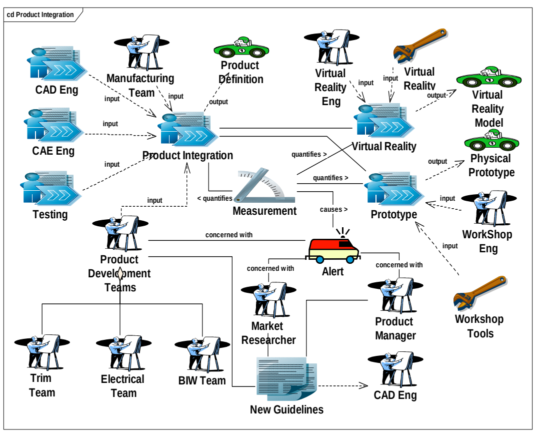

Figure 7: Testing and Validation Activities.

4. Conclusions

In this paper we model the new design activity process vehicle development process, using a specific language UML2 derivate. The high level vision allows all involved parties to have a generic overview of the project status, anticipate project drawbacks that allow connections and adjustments at an earlier stage. This early connections avoid time and cost losses. The several actors of such complex process can any time access risks and define recovery plans that will allow the successful achievement of the global final goal. This language allows a common business notation and with a specific ontology we can define a knowledge space used to share knowledge among the different actors and systems.

Based on this gathered knowledge it is possible to propose a platform to:

- Time reduction in the setting phase of the project;
- Ergonomic studies and vehicle setting phases are unified in one parametric product;
- Standardization of the vehicle process setting and establishing a common language and notation;
- Central data base of country homologation and safety issues, that could facilitate harmonization among different countries.

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