VDML: A MODELING LANGUAGE FOR NEW VEHICLE DEVELOPMENT

João Ferreira, Francesco Furini, Sandra Augusto
ISEL Pininfarina Volkswagen
jferreira@deetc.isel.ipl.pt f.furini@pininfarina.it sandra.augusto@oniduo.pt

Abstract
Designing 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 vehicles attributes. Understanding how these process interact and how they are aligned with other and process while they should supporting the operation tasks of the conception of a new vehicle at minimum time and cost. The first step to achieve this goal is to define a new UML profile (VDML language) based on the extension mechanics of UML (industry standard language) to assist business process description and consequent improvements originated from a high level vision.

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increased competition, new market requirements, greater customer focus, vastly improved information technology, outdated business practices, etc.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 [1]. 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. Stereotypes have been given a special attention together with the idea of the Model Driven Architecture (MDA, [2]) and generative programming approaches, which is gaining popularity. UML is proposed to be used into two senses: (1) business process modeling; and (2) software process modeling. Modeling design process of the vehicle development specializes on describing how activities interact and relate with other design process activities while supporting the operation of the business. Can also be used for multiple purposes, such as general overview of
complete activities and process, facilitating human understanding and communication (lots of external actors participate on these tasks: dealers, insures companies, country regulation, etc), supporting process improvement and re-engineering through business process analysis and simulation [3, 4], automating the execution of business processes [5,6] and facilitating coordinated business and system development by keeping the alignment between processes and their support systems [7].

UML profiles are UML packages of the stereotype «profile». A profile can extend a metamodel or another profile [8] while preserving the syntax and semantic of existing UML elements. It adds elements which extend existing metaclasses. UML profiles consist of stereotypes, constraints and tagged values.

A stereotype is a model element defined by its name and by the base class(es) to which it is assigned. Base classes are usually metaclasses from the UML metamodel, for instance the metaclass «Class», but can also be stereotypes from another profile. A stereotype can have its own notation, e.g. a special icon. Constraints are applied to stereotypes in order to indicate restrictions. They specify pre- or post conditions, invariants, etc., and must comply with the restrictions of the base class [8]. Constraints can be expressed in any language, such as programming languages or natural language. We use the Object Constraint Language (OCL) [9] in our profile, as it is more precise than natural language or pseudo code, and widely used in UML profiles. Tagged values are additional meta attributes assigned to a stereotype, specified as name-value pairs. They have a name and a type and can be used to attach arbitrary information to model elements.

This profile will allow in the Activity Diagrams representing business process goals, and their performance measures. In this paper we proposed a UML profile for modeling process in the new vehicle development.

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 (Figure 1). 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 and can be classified and implemented as «Tracks», «Laboratory», «Workshop Tools», «Applications» (e.g CAx Application) and «Database»; (4) «Information» is also input/output of activity and can be classified and implemented as «Production», «Homologation Rules», «Competitors», «UserNeeds» and «Internal Products»;(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», «Performance», «Cost» and «Cycle Time». This means that the stereotype «Measure» can be described in four 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», «Performance» 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.

![Figure 1: UM Profile for New Vehicle Process Development.](image)

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, responsbly 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.

2.1 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 [10,11,12]. 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; (5) personnel development. In this view we intend capture relations among actors which participate
on the activity process, capture in a contextualizing way the communication between actors, display actors responsibilities and skills.

Figure 2: Identification of main actors.

In the advanced engineering activity of a vehicle program, the main actors, illustrated in Figure 2 and 3, are:

- **CAD Engineers**, demonstrate 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 models to within 0.2mm of engineering feasibility data, within the required time frame perform feasibility and packaging studies and verify solutions to be in compliance with regulations;

- **Styling and CAS Engineers** 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. Define stylistic properties and then creating computer-aided styling (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 disconnects in concurrent aesthetic and engineering design, to the broken feedback loop from downstream design/engineering processes.

- **CAE Engineers** are 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, safety, vehicle dynamics, thermal management, aerodynamics, fuel economy and performance, package, weight, electrical systems and electronics.

- **Testing and Validation Engineers** 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 feedback is essential to the approval of the work produced by the engineers and can originate severe corrections and changes to their work.

- **Product Development Teams**, have 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 predefined speaker that reports to the product manager and interacts with the other product development teams.
- **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.

- **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 management.

- **Market Researchers** are responsible to collect information about clients’ needs and 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.

- **Purchasing Team**, have the responsibility of finding and negotiate price supplier for the new car parts identified in the new product.

- **Reverse Engineer** 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.

![Figure 3: Use case view of process design of a new vehicle.](image)

**Activity View:** Activity Diagrams are a part of the behavioral models of UML 2 [8] and are used for modeling business processes as well as for describing control flows in software. UML profiles are an extension mechanism for building UML models for particular domains or purposes [8]. We utilize this well-defined way to extend the UML 2 Activity Diagram with business process goals and performance measures adapted to the process design of new vehicle:

- The modeling of goals is a critical step in the creation of useful process models, as they allow:
  1. to structure the process design;
  2. to evaluate the process design;
  3. to better understand the broader implication of the process design and;
  4. to evaluate the operating process [13].

  This is made explicitly visible by the UML 2 profile.

- The business process models as well as the extensions based on the UML profile can be easily created, presented and edited with existing UML modeling tools, as almost all newer UML tools support UML profiles.

With business process reengineering Davenport, Hammer and Champy create a new discipline and provided the theoretical background for business process modeling. The Workflow Reference Model [14] defines a business process as a set of one or more linked activities which together realize a business goal. This definition extends the definition proposed by Davenport and Short [15] stating that a business process is a set of logically related tasks performed to achieve a
defined business goal. Most approaches to business process modeling concentrate on some sort of process map or diagram, which shows how activities are scheduled in the course of a business process. The Object Management Group has recently summarized the basics of process diagrams in its upcoming UML 2.0 activity diagram notation [8]. Similarly, the BPMI working group has just completed BPMN, a notation especially designed for describing processes in business process diagrams [16]. Still, UML 2.0 activity diagrams and BPMN are quite similar when compared at a high-level of abstraction. In addition to these notations there are others like the IDEF notation family and the proprietary notations supported by process and workflow modeling products.

The main activities divided by organizational units are illustrated in Figure 4, and a detail activity view is proposed of each activity. For example we illustrated the CAD activity on Figure 5. CAD Engineer is responsible to achieve the goal of the cad drawing part, using CAD software (e.g. Catia V), and taking in account ergonomics and homologation restrictions, functional requirements (parts integration and manufacturing restrictions) and concurrence products. This activity is measured working time, resources taken (e.g. software, man power) and quality of the output taking in account initial specification requirements. Any failure on requirements, established time and resources will generate and trigger output (alarm) to product development team which has the general technical responsibility of the development of a new vehicle. Modeling all these activities will provide better activities coordination (high level vision is available), decreasing development time (alerts, will generates faster contain action), right product or service, i.e., the right deliverable, with a high degree of performance measured against cost, longevity, service and quality. In each activity a local measure and a global (final product impact) is available.

Figure 5: CAD activity view using VDML language proposed.

3 Conclusions

This paper has presented the fundamental concepts towards a new language, specific for the design of new vehicle, UML 2 derivate. A domain-specific language captures ontology of its domain; and each implementation (a generator, interpreting engine, or simulator that executes the language's statements) encapsulates a framework of components and design patterns. New stereotypes specific for this subject were developed and integrated with activities goals and performance measures into UML 2 activity diagrams. This profile provides explicit performance measures time, cost and quality of each activity. Two views were proposed to simplify the process study Object view we define relations among different actors, responsibilities and skills and on roll model view describes activity flux.
4 References