Enterprise Engineering Method supporting Six Sigma Approach

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ABSTRACT
Enterprise Modeling (EM) is currently in operation either as a technique to represent and understand the structure and behavior of the enterprise, or as a technique to analyze business processes, and in many cases as support technique for business process reengineering. However, EM architectures and methods for Enterprise Engineering can also used to support new management techniques like SIX SIGMA, because these new techniques need a clear, transparent and integrated definition and description of the business activities of the enterprise to be able to build up, to optimize and to operate an successful enterprise.

Keywords: Enterprise Engineering, Process Modelling, SIX SIGMA, Process Management Tool

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Modeling tools: Development of a tool supporting object oriented methodology for enterprise modelling
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1 Introduction

In today's highly competitive global economy, the demand for high quality products manufactured at low costs with shorter cycle times has forced a number of manufacturing industries to consider various new product design, manufacturing, and management strategies. Recently, due to the rapid advances in Information Technology (IT), new paradigms have successively emerged such as e-commerce, automation of business processes to process orders with internet via Enterprise Portals. To cover these new requirements methods like Concurrent Engineering, Business Process Engineering and more Enterprise Engineering (EE) are needed. A new paradigm in this area of management strategies is SIX SIGMA. The main goal of SIX SIGMA is to optimize the performance of processes (Magnusson, 2001 and Magnusson, 2004).

Enterprise Modeling (EM) is currently in operation either as a technique to represent and understand the structure and behavior of the enterprise, or as a technique to analyze business processes, and in many cases as support technique for business process reengineering. However, EM architectures and methods for Enterprise Engineering can also used to support management strategies like SIX SIGMA, because these new approaches need a clear, transparent and integrated definition and description of the business activities of the enterprise to be able to build up and operate an Enterprise with high performance business processes.

Other indicators which influence the quality of products and processes are customer orientation, cultural issues, adequate organization of work, quality of leadership, Policy Deployment (Akao, 2004). These indicators have to be covered, when we deal with the determination of adequate and reasonable criteria for the assessment and measurement of the “Quality of an Enterprise” and for the operation of enterprises in an adequate and reasonable manner

This paper provides an overview of architectures, methods and tools for Enterprise Engineering. It then points out substantial results achieved so far as well as presents a methodology called IEM (Integrated Enterprise Modelling) and a related tool in more detail, which supports the SIX SIGMA approach.

2 Enterprise Architectures, Methods and Tools

2.1 Architectures and Methods

Major research and development activities in the area of software engineering have resulted in following methods for system description and specification:

Information Modelling (Mertins, 1994): Entity Relationship (E/R); STEP/EXPRESS (especially for product data).

Functional and Process Modelling (Mertins, 1994): Structured Analysis (SA), Structured Analysis and Design Technique (SADT); Agent- Based Methods; Petri-Net-based Methods; Process Specification Language (PSL).

Object Oriented Modelling (Jacobson, 1994; Coad, 1990): Object Oriented Software Engineering (Jacobsen); Object Oriented Analysis and Design (Coad/Yourdon); Unified Modelling Language (UML).

Major research and development programs for CIM have resulted in the following methods or architectures for enterprise modeling:

IDEF (ICAM Definition Method). It is made of a series of modeling methods comprising IDEF0 for functional modeling, IDEF1x/EXPRESS for information modeling, IDEF3 for business process modeling, IDEF4 for object modeling and IDEF5 for ontology modeling (Mayer, 1991).

GRAI-GIM. GIM (GRAI Integrated Methodology) is a methodology for design and analysis of production systems based on the GRAI method (Doumeingts, 1995). It includes modeling methods (GRAI grid, GRAI nets, IDEF0, MERISE) and focuses on decision system analysis of the enterprise.

CIMOSA (CIM Open System Architecture). It provides guidelines, architecture and an advanced modeling language for enterprise modeling covering function, information, resource and organization aspects of the enterprise (AMICE, 1993; Vernadat, 1996; Vernadat, 1998).

PERA (Purdue Enterprise Reference Architecture). This is a detailed methodology for enterprise engineering of industrial plants (Williams, 1997). It does not provide modeling constructs.

GERAM (Generalized Enterprise Reference Architecture and Methodology). It is a generalization of CIMOSA, GIM and PERA (IFAC-IFIP, 1997). It provides a methodology for enterprise engineering (PERA and GIM), a system life cycle (from PERA) and constructs for modeling (CIMOSA).

2.2 Tools for Modelling

Many modeling products now exist on the market place (e.g. ARIS ToolSet, FirstSTEP, Bonapart, PrimeObject, or CimTool to name a few). Some of these packages are just modeling tools, others are more analysis tools and some even include a powerful simulation engine to evaluate performances of the system or analyze enterprise system behavior. Other tools are workflow management systems and include a modeling environment and a model enactment environment to control business processes. Enterprise modeling is currently in operation either as a technique to represent and understand the structure and behavior of the enterprise, or as a technique to analyze business processes, and in many cases as support technique for business process reengineering (Vernadat, 1999).

3 SIX SIGMA Approach

A common definition for processes is “activity or chain of activities which transform production factors like Materials, Machines, Work, and other resources, into products or service performances”. Production factors can be controllable or not controllable (it may be too cost intensive to control). The SIX SIGMA model for process optimization can be expressed as function

$y = f(x)$.

y is the result variable (characteristic of a process) and *x* is the production factor (represented by characteristics of the production factor). Goal is to find the production factors x_s which lead to better values of the result variable y. Each process has one or more specific characteristics or attributes, which can be described or documented. Theses characteristics are used to measure the performance of

processes (Magnusson, 2001). There are two kinds of characteristics: continuous (e.g. length, time or temperature) and discrete (e.g. correct/wrong, acceptable/not acceptable). The measurement of these characteristics shows the **variation** of the values of the process characteristics. Goal of process optimization is to reduce the variation of these values of process characteristics. Each process has a **throughput time** and a **performance indicator** (see **Fig. 1)**. In SIX SIGMA the optimization of both is based on the availability of forecast, the reduction of deviation and the optimization of centration (Magnusson, 2001).

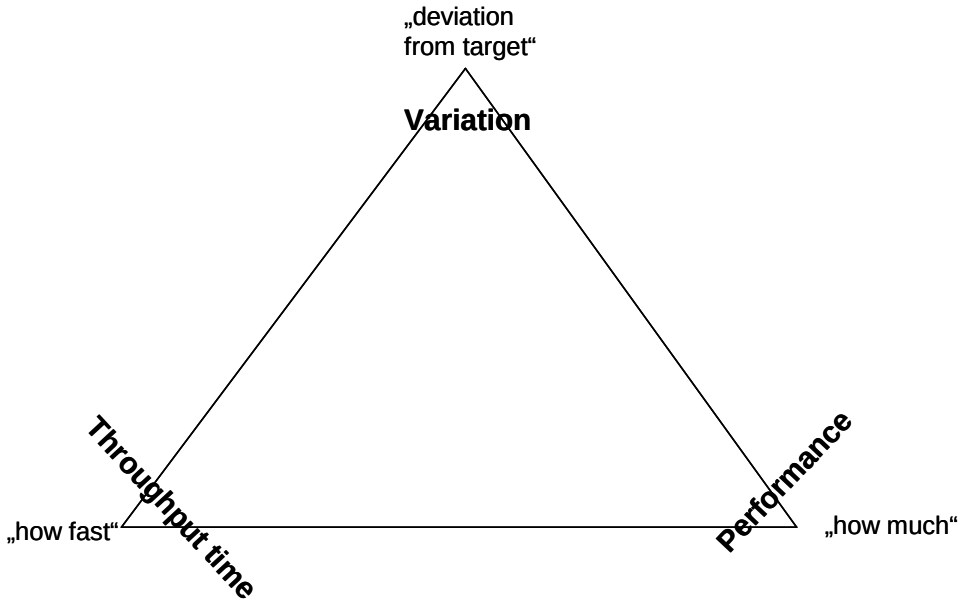

Figure 1: The SIX SIGMA performance and optimisation triangle for processes

4 Integrated Enterprise Modelling (IEM)

The method employs the object-oriented approach to describe information and functions of objects as views on a single model of the system 'manufacturing company' integrally. The core of the model structure contains the views 'business process model' and 'information model'.

In the model the manufacturing processes and all activities that in reality are related to the production are described by functions and business processes that refer to certain objects.

The basis for the development of the model as a description of an individual company is formed by the object classes 'product', 'resource' and 'order'. The required corporate data and functions are assigned to these objects when creating the model. The relations between the objects are also determined. The result is that all tasks, the process organization, the corporate data, the production facilities and all components of the information system are registered comprehensively on any desired level of detail (Mertins, 1998).

The view 'business process model' emphasizes the tasks and business processes that are executed on the objects; the view 'information model' emphasizes the structures and features that describe objects. You are enabled to view **one** integrated model of the company from different angles. Business processes and the related information are described integrally in a model core. The information

systems, the organizational structure, quality requirements and quality profiles constitute user views that relate to the model core. This enables you to evaluate process-organizational alternatives or modifications with regard to the effects on the control, the quality, the system support, the organizational structure and the staff's qualification profile (Mertins, 1996).

Object-oriented techniques are broadly used for the development of applications in various areas. The main advantage of this approach is the entirety of data and functions operating on these data. Provided with the powerful inheritance mechanism it yields models which are more stable and easier to maintain than those based on other modelling approaches.

In order to utilize its advantages and to provide a comprehensive and extendable enterprise model, the IEM method uses the object-oriented modelling approach, thus allowing the integration of different views on an enterprise in one consistent model and the easy adaptation of the model to changes within the enterprise.

The generic classes Product, Resource and Order form the basis of Integrated Enterprise Modelling for developing models from the user`s point of view. They will be specialized according to the specifics of an individual enterprise. Each generic class prescribes a specific generic attribute structure, thus defining a frame for describing the structure and behaviour of objects of its subclasses. Real enterprise objects will be modelled as objects of these subclasses (Mertins, 1998-2).

Required enterprise data and the business processes, i.e. the tasks referring to objects, are structured in accordance to the object classes (see below). Furthermore, the relations between objects are determined. The result is a complete description of tasks, business processes, enterprise data, production equipment and information systems of the enterprise at any level of detail.

On a European level the CEN/TC 310/WG 1 developped an European pre-standard (ENV 12204) of „Constructs for Enterprise Modelling“ that defines modelling elements which are necessary for the description of Objects and Business Processes of an Enterprise. It was mainly based on IEM Methodology of Fraunhofer IPK and the results of CIM-OSA project result (ENV, 1996).

On international level in ISO TC 184/SC 5/WG 1 „Modeling and Architecture’ (ISO 14258: Concepts and Rules for Enterprise Models) the studies on Integrated Enterprise Modeling were a basis for the definition of concepts and rules for a modelling framework that should be open to a number of different modeling methods (ISO, 1997). Further work in that area will be done in a Unified Enterprise Modelling Language (UEML) (Jochem, 2002).

Fig. 2 gives an overview of the modelling elements of IEM (Mertins, 1999). The object oriented modelling approach secures the reusability of modelling constructs and models for different purposes and enterprise types. Libraries of object classes and business processes can be created.

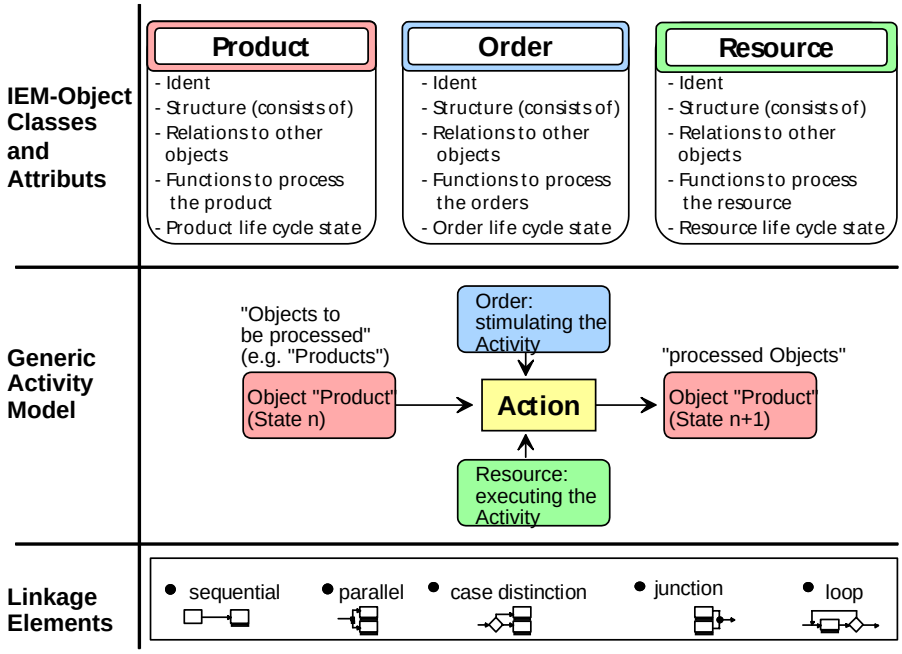

Figure 2: IEM Modelling Elements

5 Software-Tool MOOGO

The process management tool MOOGO supports the method of object-oriented business process optimization. The universally usable tool to describe, analyze and optimize operational structures and business processes enables you to comfortably describe and purposively analyze products, resources, orders and the related business processes. Advantages of the use of the tool include the systematization of the planning and optimization processes and the reusability of the enterprise model for all projects and user views that concern corporate planning, such as information systems, controlling, quality management and organizational development. You may also generate standardized documents according to ISO 9000ff. automatically. This reduces the certification process significantly. Class Libraries for specific application fields are available (e.g. ISO 9000 ff., order processing, one-of-a-kind production etc.) (Mertins, 1999).

The tool enables you to reuse partial models and provides libraries with reference models. There are interfaces with the MS WINDOWS application programs WINWORD, EXCEL and ACCESS. Additionally predefined evaluation functions for standard queries on the model are provided by the tool. These functions can be parametrized by the user. **Fig. 3** shows the main components of the MOOGO system including the User Management.

6 Usage of IEM to support SIX SIGMA

With the usage of the IEM Method it possible to represent the characteristics of processes and the production factors by attributes of an enterprise model. Production factors can be described by the resource objects and their attributes of the IEM method. The result variables of the SIX SIGMA function (y = f(x)) can be represented by attributes of the IEM-product object. The characteristics of

processes can be described by attributes of the IEM activity. The needed control information for the execution of this function can be described by attributes of the IEM-order object.

The resulting enterprise model of described processes and described production factors of the whole enterprise modelled with the software tool MOOGO, can be used to measure, analyse, optimise and evaluate the performance indicators described within the model.

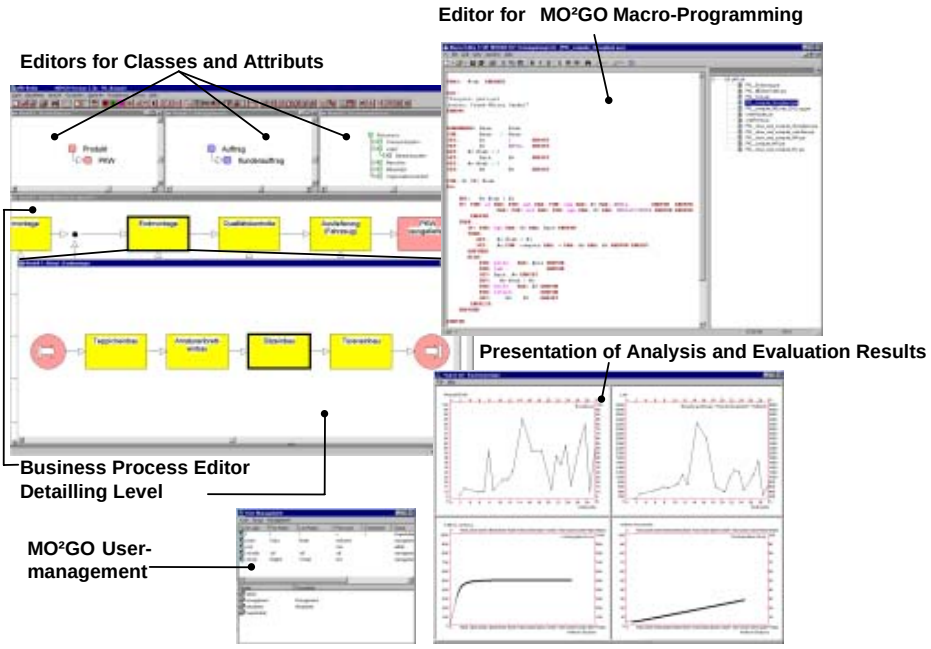

Figure 3: Main Components of System MOOGO

The user is able to follow the approach of SIX SIGMA to reduce the variation of the process attribute values. He can reach forecast related to specific measures he apply in his enterprise by analysing and evaluating the described attributes of processes and production factors. He can get performance indicators for the application of these new measures within his enterprise. He also is able to analyse and to reduce the deviation of the values of the process attributes with the help of the model and the software tool functionality.

The aspects ”throughput time” and ”performance indicator” of the SIX SIGMA approach are implemented as specific evaluation procedures within the MOOGO tool and can be used to analyse and optimize processes described with the IEM method in an enterprise model (see **Fig. 3**).

Additionally the enterprise model is a basis for the continuous optimisation of the processes of the entire enterprise using Six Sigma Approach. The enterprise model established in MOOGO is able to represent all information needed to follow the DMAIC-Cycle (Define, Measure, Analyse, Improve, Control) and to support the tasks in the different phases (see **Fig. 4**).

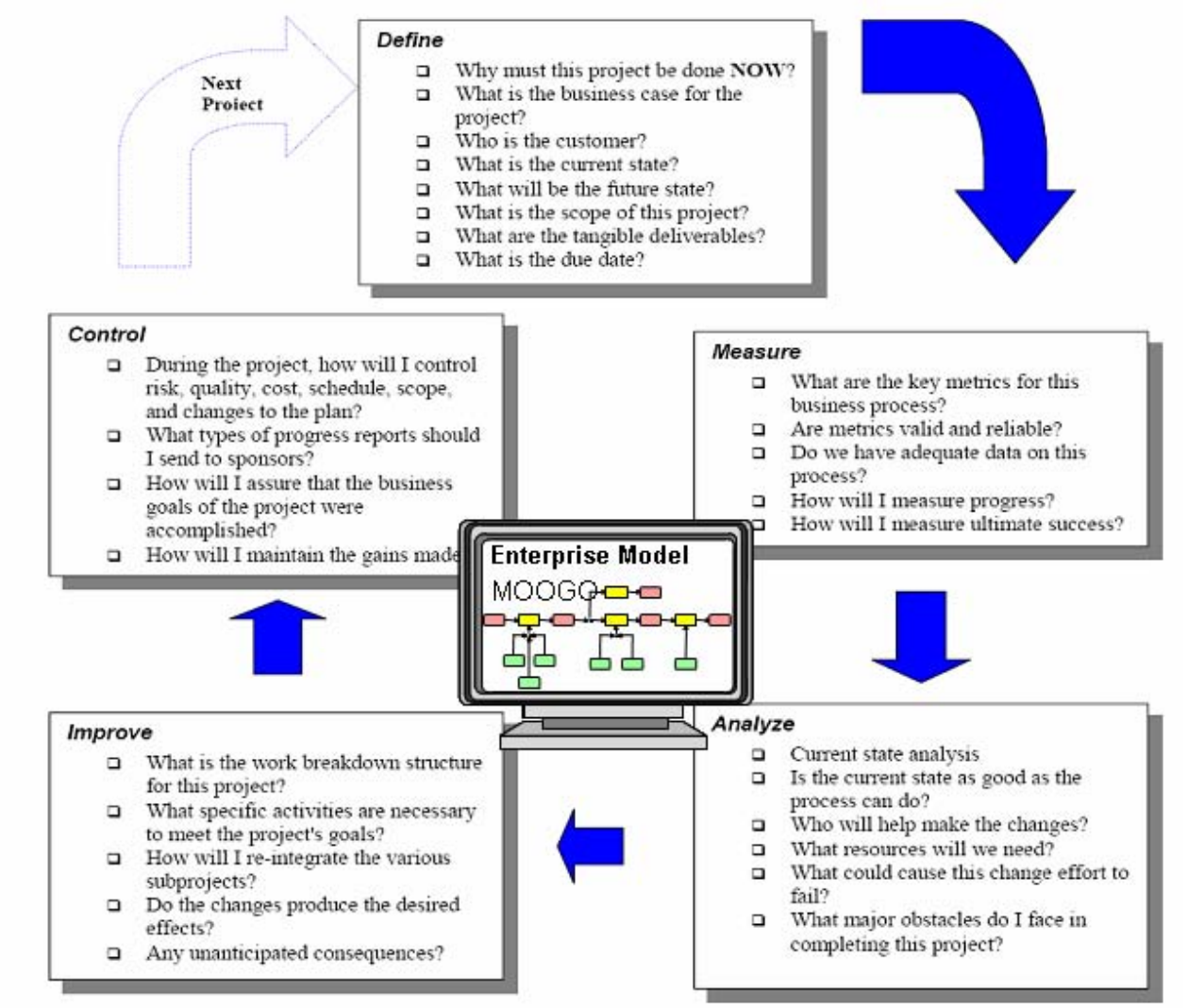

Figure 4: Enterprise Model supporting DMAIC-Cycle (according to www.isixsigma.com)

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