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Sustainability Engineering as an Enterprise Quality Requirement

Roland Jochem

Berlin University of Technology, Germany

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Abstract

Modeling is a broadly excepted analytic instrument and planning tool. Today, modeling is mainly applied for engineering and physical purposes and covers a short time horizon compared to intergenerational justice. In parallel, sustainability is gaining more importance for the industrial planning because themes like global warming, child labor, and compliance with social and environmental standards have to be taken into account. Sustainability is characterized by comprehensively examining the three dimensions economy, ecology and social questions as well as their long-term perspective. Adequate indicators and an adaptation of Quality methods and procedures are necessary to evaluate the sustainability of enterprise processes. A further challenge is the consideration of sustainability effects coming from the usual manufacturing process structure of a value creation network, in particular from cross-enterprise cooperation and geographically distributed production. This article examines in a first step the state of technique related to sustainability and modeling of sustainability within enterprises and cross-Organizational. It describes then an approach to model sustainability from different perspectives of an enterprise.

Keywords: Modeling, Quality, Sustainability, Value Creation Network.

Introduction

'Making a development durable and viable for the future, means that the current generation meet their needs without threaten the ability of a future generation to satisfy their own needs' in this way the Brundtland-Report from 1987 defines sustainable development. Sustainability is seen as a process of change, by whom the use of resources, the structure of investments, the orientation of technological improvements and the institutional structures have to be adjusted and balanced between the current and future needs. Such needs are for example to ensure healthy food, availability of resources and a stable and safe social environment. In parallel to the long-term aim of an intergenerational justice the origin for a sustainable development was sharpened by the German Bundestag. In 1998 a committee of enquiry put sustainability on 'Three Columns' and pointed it out as a 'concept of enduring development viable for the future and related to the economic, environmental and social dimension of human existence'. Sustainability can unfold its full potential just if it finds a way into a broad range of economy and society.

Nowadays the modeling of technical and economic issues is a common analytic instrument and planning method. Presently, enterprise models mostly focus on clearly delimited engineering and organizational questions. If sustainability aspects of the issues should be analysed then additionally the implications on the economic, environmental and social dimensions have to be taken into account (Figure 1).

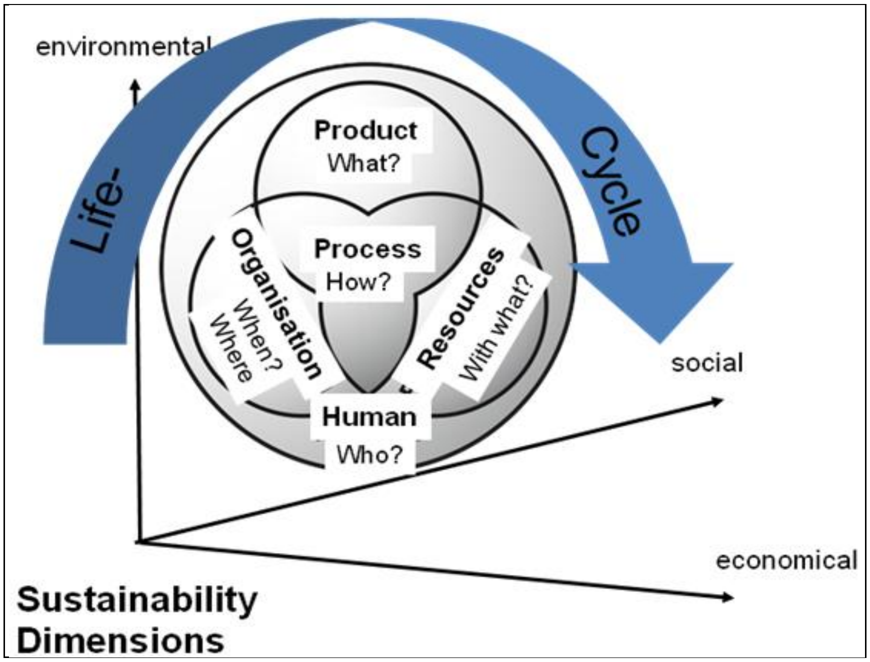

Figure 1: Sustainability Dimensions.

At the same time also a relation to the long-term development has to be facilitated. Appropriate indicators are requested to perform such combined analyses both bridge the local analysis content with all sustainability dimensions as well as the long-term orientation. Modeling methods and procedures have also to be adapted to the advanced content and time perspective. But, it is not that easy to gain a sustainability-integrating investigation of a part from a supply net compared with a pure material flow-oriented analysis. This is especially a challenge because many manufacturing processes are organized across enterprise borders and are geographically distributed, often global. As an example, the choice of a 'sustainable' material for a product might induce an environmentally non-beneficial coating procedure in a later stage within the value creation chain or induce a higher scrap rate during the final manufacturing.

At the moment process modeling related to different planning horizons is applied for example for organizational design of enterprises, for decision support at the manufacturing site and in operative quality control systems design. The modeling of sustainability aspects requires a stronger integration of fields that are currently mostly analyzed independently, especially, along the different decision making levels within an enterprise as well as along a supply net crossing enterprise borders. Moreover, the product life cycle has in important influence on the sustainability (see Figure 1).

This paper examines in a first step the state of technique related to sustainability, modeling of sustainability and the relation to Quality Management in an enterprise.

State-of-the-Art in Modeling of Sustainability in the Industrial Environment

In order to structure the related research, this chapter first examines which general sustainability concepts are available for single enterprises and a set of enterprises along value creation networks. Then, modeling approaches related to an individual production site and to complete value creation networks are reviewed.

With regard to the design and operation of sustainable industrial value creation networks, concepts and tools of environmental management and material flow management have to be taken into account and have to be integrated into a Sustainable Supply Chain Management concept. Regarding this topic accepted norms and standards are already defined internationally. Thus, the material flow management provides on the one hand solutions to reduce the environmental impact by the reduction of anthropogenic emissions and by substitution of materials. On the other hand, the environmental management solutions propose ways to improve the corporate environmental management (ISO 14001) and the operational environment performance (EMAS). The ISO 14001 is an environmental management system, which systematically anchors the environmental protection within the management in order to take account of environmental aspects in all daily tasks and in all strategic enterprise decisions.

The EMAS is based on the 'European Union Eco-Audit Regulation' by the European Commission from 1993. It regulates how all the effects of a production site on the environment have to be recorded assessed and documented. In the field of social accountability SA8000 and ISO 26000 are the world's first certifiable standards for the expansion of the company's reputation through socially responsible corporate governance. Based on the international convention of human rights and selected rules of the International Labor Organization (ILO), the SA8000 includes nine thematic areas. Among those issues SA8000 includes prohibition of child labor and forced labor, health and safety, freedom of association, prohibition of discrimination, limits on working hours, an adequate remuneration and management systems sufficient to guarantee compliance with the standard's conditions.

However, the degree of implementation of these standards is – compared with the ISO 9000 – neither comprehensive nor area-wide. Defined standards remain without significant effect, as long as they are not perceived and implemented. However, a study on environmental and social standards in the automotive industry showed in 2004 an overall positive attitude to questions of sustainability. 97% of the companies consider sustainability in general as important or very important, 92% classify sustainability for the automotive industry as important or very important and 79% consider environmental and social standards (ISO 14000, SA8000, and ISO 26000) as very helpful to assist and cultivate sustainability. Often companies ostensible require compliance with standards such as ISO 9000, ISO 14001 and EMAS from their suppliers. Nevertheless, a holistic link and integration of environmentally-focused management concepts such as material flow management and environmental management with the supply chain management is not yet identified. First approaches to that can be seen in the EFQM Model. In its Assessment Model it contains an integrated approach to describe and analyze indicators for different perspectives of an enterprise from customer satisfaction, employee satisfaction to environmental and social responsibility. Other more operational approaches derived from lean management principles like “5S” (structure, systematize, sanities, standardize, self-discipline) provide checklists and data sheets to document and analyze sustainability indicators related to competitiveness, environmental and social responsibility in an integrated manner.

According to a study from the ETH Zurich the companies see the lack of appropriate software as the main obstacle to not have introduced a Sustainable Supply Chain Management. However, some companies already fail by the definition of appropriate metrics and their weightings, as well as the continuous measurement of the indicators.

With the title ManuFuture a research roadmap related to future production within the European Seventh Framework Program (2007 to 2013) has been defined. This roadmap is supported by Germany from the Fraunhofer Society, universities, associations and 200 companies. Beside the primary research tasks, the areas ‘High Performance Manufacturing’ and ‘Digital Factory/ Adaptive self-organizing cooperative processes/ reconfigurability of machinery’ appear as highlights. These are suggestions, mainly to accelerate production processes and design them more effective, by computer use. Anyway, it is not declared more precisely how to consider the operational, economic, environmental or social conditions and consequences. In the USA the theme ‘Next Generation Manufacturing’ focuses primarily on computer applications to increase the self-configuration of production facilities as well as a strengthening of life-cycle analysis of products and production facilities.

In the future, the existing techniques for enterprise modeling have to be brought together with the demands of sustainability, especially coming from the integration of economic, environmental and social perspectives. For this purpose a framework for the different modeling approaches is needed in a first step to be able to structure their relationships among each other and in the second step to model the required enrichment of sustainability needs.

With respect to enterprise modeling, there are different methods and tools available for the process level, e.g. the Integrated Enterprise Modeling (IEM), the Event Driven Process Chains (EPC), and the Process Chain Paradigm. The specifically important aspect of interoperability within corporate networks was examined as part of large European projects, especially IDEAS, ATHENA, and InterOP. This has led to the development of several new methods, e.g. UEML and POP*.

Concerning the design, configuration, and operation of Value Creation Networks, modeling and assessment methods (EFQM, CMMI) have been specified. However, those methods mostly refer to internal processes and not to value creation networks. Associated fields of research are for example holistic production concepts, environmentally-orientated material flow, sustainability within supply chain management, and sector specific supply chains.

The possibility to effectively apply business process modeling to the integration of different disciplines has been successfully demonstrated. The IEM offers an excellent starting point for this integration. Relevant scientific issues have used the IEM as knowledge base, for analysis, and for model and business interoperability. Experience with multi-perspective challenges has been acquired e.g. within the projects SPIDER-WIN (parallel modeling of different partners in several networks) und FLUID-WIN (interdisciplinary and cross-domain modeling).

Summarizing, there exists a wide variety of successful modeling applications. These have to be, however, more integrated with each other in terms of sustainability and to be extended for a consistent consideration of sustainability.

Approach to Model Sustainability from Different Perspectives

To define an approach that models sustainability aspects to examine this with respect to cause-effect relationships on sustainability, the authors see the following challenges:

1. Consideration of the long-term nature of sustainability in parallel to the relatively short-term industrial problems.
2. Evaluation of the impact of limited industrial problems on the economic, environmental, social aspects of sustainability.

It is considered on the principle definition of sustainability as 'permanently sustainable development of economic, environmental and social dimension'. Economic goals for the modeling are, among others, the improvement of processing time, of stock level or the routing. Their direction and the measurements are usually clearly defined. However, the environmental objectives may overlap with the economic objectives, especially if they have monetary implications. Examples are the CO2 reduction and the increase of the energy efficiency. As long as the legislature and the market provide indicators, a consideration in models is easily possible.

For environmental goals such as long-term availability of resources, recycling or efficient land use it is much more difficult to find the indicators to be used. Moreover, the cause-effect relationships are not known directly between the modeled technical-economic issues and environmental objectives in terms of value, size and time, for example, what is the connection and correlation between optimal throughput time, maximum working time and energy efficiency. Even more serious, this occurs with the social objectives, such as social responsibility (for example child labor), to respect social standards, permanent education or the need for a stable and secure social environment. In addition, the attempt to follow different objectives of sustainability may lead to a conflict of aims, both within and between the dimensions economic, environmental and social. As an impression of the scope and complexity of the indicators for real products Finkbeiner et al. gave the example of the Mercedes-Benz S-Class.

Summarizing, the presence of measurable and verifiable indicators is a prerequisite for the modeling of sustainability aspects. For technical and economic goals appropriate indicators are – as experiences show – available. For the environmental and social dimension standards such as ISO 14001, EMAS and SA8000 can provide a first set of indicators. However, these indicators represent individual aspects only, but not the sustainability of a certain decision as a whole. The relation between the indicators is not always clearly defined. A more promising approach to that respect is the EFQM Model. Here the relations between the indicators are defined and assessed in an integrated manner. But the social and environmental indicators are often defined at a relatively high level of abstraction and related to long periods of time, compared to technical or economic metrics. A more concrete description of these indicators is provided in checklists of lean management approaches like "5S". But also here the interdependencies of the different indicators are not clearly described.

Therefore, the key challenge will be to describe the objectives and indicators of the different dimensions in their relation to each other and to the business processes which are causing the values of the indicators. A further challenge is to downscale or to upscale the indicators to the level of individual enterprises and value-added networks (Figure 2).

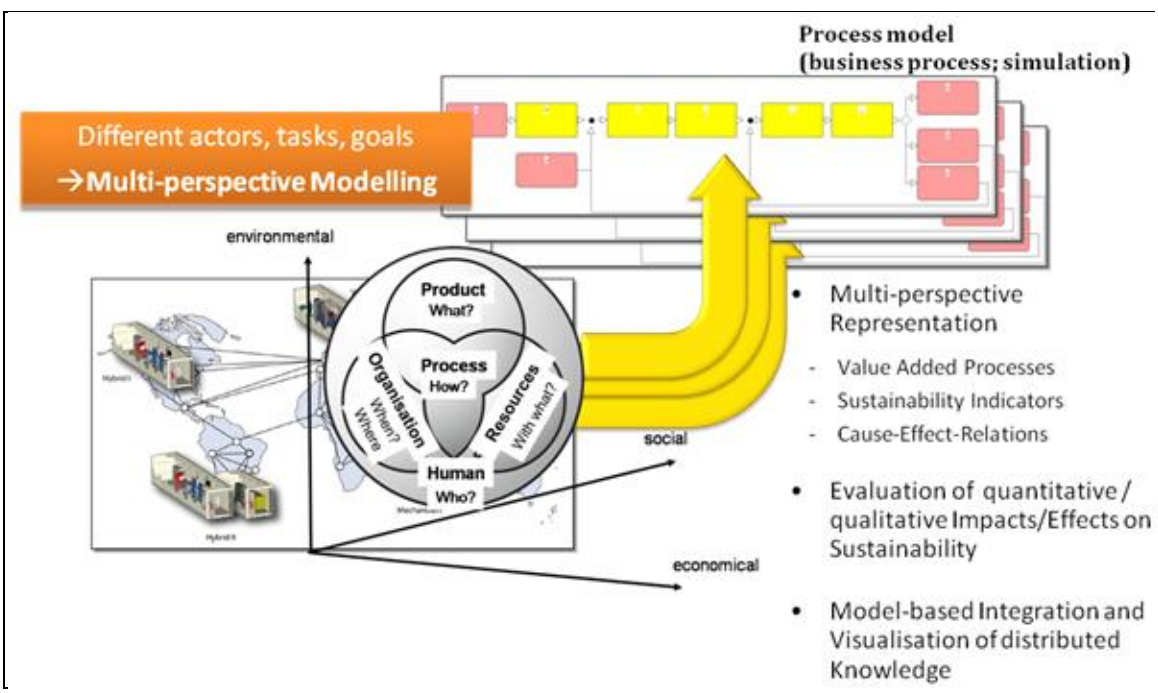

Figure 2: Sustainability Modeling.

Therefore, the way of modeling and describing (sustainability) indicators as well as their cause-effect relationships with processes and process models (business processes and simulation) have to be integrated formally to get a reliable model. By using this integrated model the company-internal and the cross-enterprise processes can be clearly described together with their alignment to the sustainability aspects. Beside this multi-perspective description of sustainability aspects a further challenging issue is the bi-directional intermediation of the modeled information with different actors. A web-based Process Assistant should provide various individually adaptable views of the model information to a large number of interested actors from society, business and science. Moreover, this community should be able to enhance the model with additional information by using the Process Assistant (figure 2).

Conclusion

The issue of sustainability got internationally specific and sharp contours, especially since the common decision of the G20 countries to limit the global warming by 2050 to a maximum of 2°C. Derived and more practical objectives and arrangements at national level will follow soon. It is very likely that the economy will be obliged to implement this. Sustainability will therefore be an essential topic in the Quality Management of enterprises. An analysis of the state of the art of sustainability and enterprise modeling gave initial starting points.

However, there is the need to develop advanced concepts and tools for the different levels of modeling. For example, at the enterprise level the cross-enterprise definition and managing of sometimes divergent goals across all sustainability dimensions (economic, environmental and social) is one of the biggest challenges. This means, that the way of modeling and description of (sustainability) indicators and their cause-effect relationships with processes and process models have to be systematically and formally combined.

Standards must be developed, enhanced and introduced as base to fully and systematically consider sustainability aspects in the industry. As base to plan sustainable enterprises progress has to be achieved in the following areas:

- Scalable system of indicators to ensure consistent evaluation of sustainability.
- Integration of different perspectives of models (indicators, cause-effect relationships, processes).

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