VERA: Virtual Enterprise Reference Architecture

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Abstract

Globalisation, outsourcing and customisation are main challenges of today not least for one-of-a-kind producers. A crucial competitive factor will be the ability rapidly to form customer focused virtual enterprises comprised of competencies from different partners by taking full advantage of ICT. To prepare for this is a complex task, in fact all business, management and planning views, and related subject areas and activities, may be involved. In order to deal with this complexity in a systematic way and secure global understanding GLOBEMEN has developed a Virtual Enterprise Reference Architecture based on GERAM. This paper describes its main contents and presents examples of its use and potentials.

1. Introduction

A crucial part of GLOBEMEN is the development of virtual enterprise (VE) architecture, guidelines, and reference models. In order to organise this work and secure a common global understanding, a Virtual Enterprise Reference Architecture and Methodology (VERAM, [1], [2]) has been developed by use of the international standard GERAM (Generalised Enterprise Reference Architecture and Methodology) [3]. Part of VERAM is VERA (Virtual Enterprise Reference Architecture) that is based on the GERA component of GERAM. This paper presents VERA and explains the potential uses of VERA. The next section introduces the contents of VERA explaining its main components. Section 3 presents examples of the use of VERA by considering the "what" of planning and the related "when" and "how", and finishes with more examples of VERA as a tool for organising the VE domain of knowledge. Section 4 draws up the conclusion.

2. The contents of Virtual Enterprise Reference Architecture (VERA)

The Virtual Enterprise Reference Architecture (VERA) is based on the modelling framework and associated concepts of GERAM named GERA [3]. GERA contains the three modelling dimensions: entity life cycle, genericity and view, see Figure 1. The life cycle phases of an entity are shown at the left, and the GERA modelling framework with all mentioned dimensions is depicted at the right. The dimension of genericity comprises the generic, partial, and particular levels. The particular level denotes the specific entity in question, whereas the partial level covers what is common to a group, or a type of entities. Correspondingly, the generic level includes what is general for the whole universe of discourse of the matter in question. The dimension of view[1] (denoting *how* you view) includes the four views: function, information, organisation and resource. Note the phase name abbreviations "I", "C" etc. in the boxes to the left. These will be used in the rest of the article.

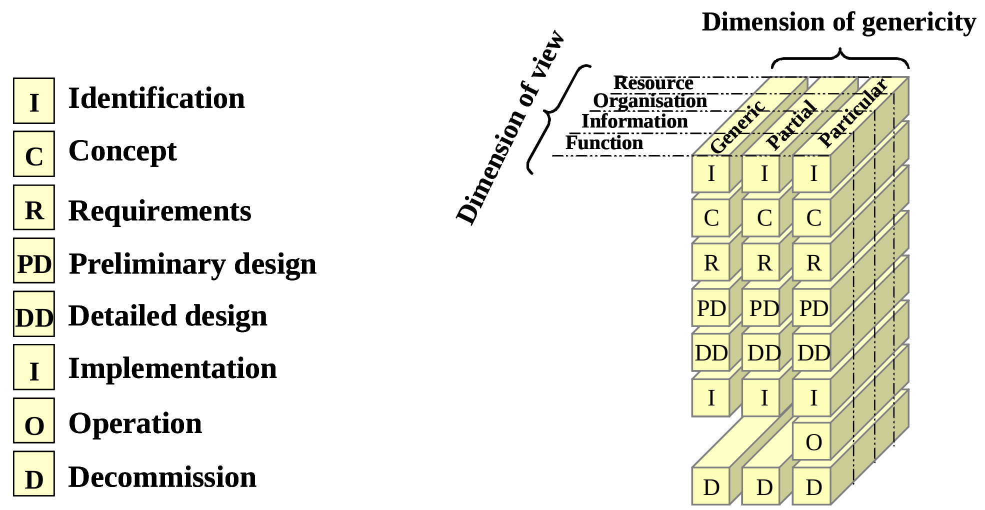

Figure 1: Entity life cycle phases (left), and GERA with all dimensions (right).

If displaying VERA by use of only the life cycle dimension, VERA is composed of three recursive entities as shown in Figure 2 to the left: a network entity, a virtual enterprise entity, and a product entity.

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[1] This view in GERAM is also named "Entity Model Contents View". GERAM introduces other views as, e.g. "Entity Purpose View", and contains several other general engineering concepts, which for reasons of space are not explicitly used in this paper.

VERA states that a group of companies form a network by assigning competencies to the network in order to be able to form VEs. In the network operational phase customer-focused VEs are formed, which produce the deliverables in question[2]. A deliverable corresponds to some product life cycle activities (called 'phases'). The phases in question will often vary from one VE to the other and correspondingly from customer to customer. Therefore two double-arrows are shown on the lines between the VE entity and product entity. Note that the enterprises forming the network are not included in the figure of VERA in this paper. This is done in order to simplify and only focus on basic structure of VERA. Also we should be aware of the fact, that the product might be an entity that produces another entity, e.g., a chemical plant that produces a chemical compound.

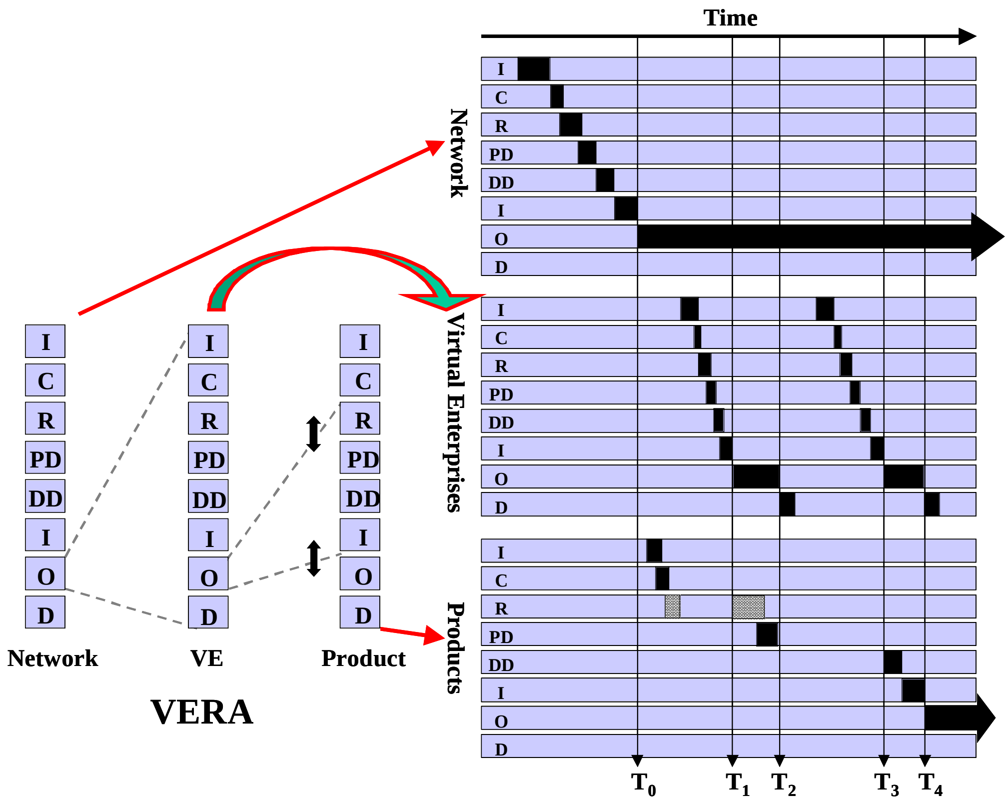

Figure 2: VERA (left) and example of life history (right).

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[2] Non-network members might be included in the formed VEs as, for instance, standard component producers. Relationships between network members can vary from ownership as one extreme to a "Yellow Page"-relationship as the other extreme. In practice the degree of mutual engagement will define the network – an issue not dealt with in this paper. See references for a further discussion.

All in all a VE is defined as: *a customer solutions delivery system created as a temporary, re-configurable, and ICT enabled aggregation of core competencies.*

By adding the time dimension to VERA it is possible to sketch an example of a so-called *life history* of a network – see Figure 2 to the right. In this part of the figure the three VERA entities are drawn above each other in order to make the presentation possible. Note the conformity with traditional Gantt-charts, and in this way a first introduction of planning issues.

At time T_0 the network has been set up and goes into operation. Shortly after a customer identifies the need for a product (i.e., carries out the product life cycle phases "Identification", "Concept", and part of the "Requirements") and subsequently asks the network for full requirements specifications and a quotation. At time T_1 the network has set up a quotation VE, which commences operation and creates the needed product specifications for the quotation, here corresponding to a completion of the product life cycle phases "Requirements" and a carrying out of "Preliminary design". At time T_2 the quotation work is finished, and the VE is decommissioned. Subsequently, the customer accepts the quotation and the network sets up a production VE. At time T_3 the production VE goes into operation and produces the product, which corresponds to the product life cycle phases "Detail design" and "Implementation". At T_4 the product is finished and delivered, and the product goes into operations (traditionally operated by the customer) whereas the production VE is decommissioned. During product operation service VEs could be established to maintain or repair the product.

3. Use of VERA

Good management can be boiled down to asking the right questions at the right time and determining the answers in the right way by use of the right methods. Crucial for doing this is to be able to define and frame: *what* to consider, and *when* to consider (in this case: when in the life history – compare the right side of Figure 2). These questions relate to *how* to decide on *what* and *when*. We will deal with these questions below.

3.1 Issues of planning for virtual enterprises – VERA and what to consider

Figure 3 depicts VERA including all three dimension of the GERAM modelling framework. Three numbered boxes with arrows have been included as examples to discuss. Box number 1 is in the product requirements phase and points into the partial and generic level. Products are very different from industry to industry. Examples of issues to consider here could be: do usable reference models for the product in question exist? Is it possible and does it pay for the network to develop its own general requirement models in order to obtain reuse and repeatability? These questions typically should be raised when setting up a VE-focused network. For a specific VE the product related question could be (if no reference models are instituted yet): is it possible to reuse parts or modules of previous solutions? As part of an experience collection in the decommission phase of a specific VE the question could be: should already established product reference models be further developed for future use? If so, it would result in a network modification. A use of the view dimension could narrow down the fields of investigation. This could be a consideration of requirements as regards product information exchange (information view), or product operator requirements (resource view) besides functional task or design requirements.

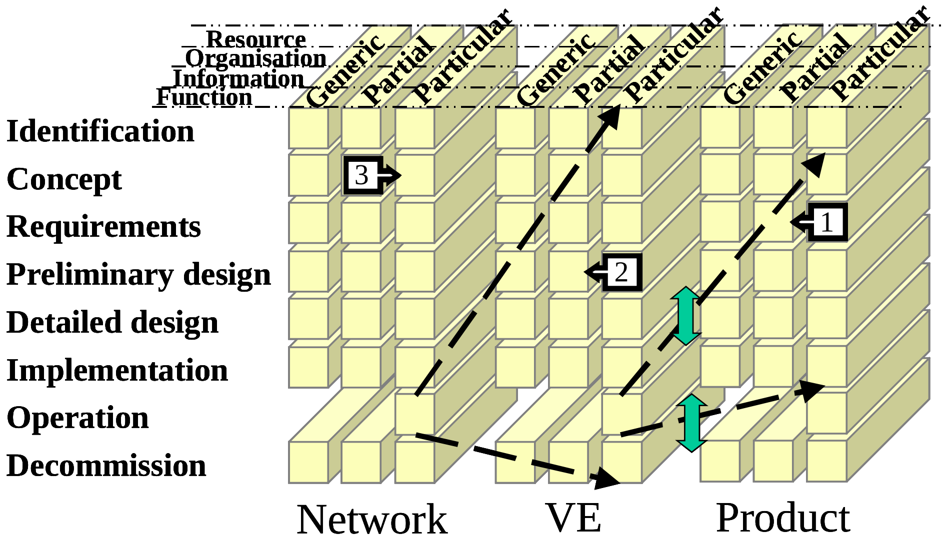

Figure 3: VERA depicted with all modelling dimensions.

For box number 2 the questions could be: which available VE configuration tool or VE infrastructure modules to use in the set-up of a VE or VEs? If all VEs to be produced by the network are considered, the question is asked in the network requirements phase, and final choices are made in the network design phases. The issues corresponding to box 2 also could concern legal/contractual issues, risk models, enterprise applications etc., that is, all issues of relevance for an overall preliminary design of a VE as a project organisation with geographically dispersed partners. Again the view dimension can help narrow down the issues in question as described above.

Box number 3 in the concept phase at the partial level of the network entity contains reference models of visions, missions, strategies, operational concepts, etc., for different types of networks meant to be used as inspiration when setting up a particular network.

The issue of reference models for virtual enterprises are further treated in [4] by use of more elements of GERAM.

Two different types of VEs have already been mentioned. The product life cycle phases can be used to distinguish between different VEs as shown in Figure 4. This terminology will be used in the following sections well aware that terminologies differ from industry to industry.

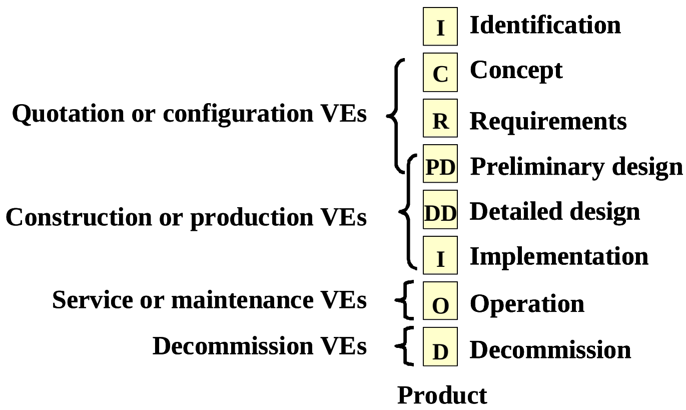

Figure 4: Classification of different VE's by reference to product life cycle phases.

3.2 Issues of planning for virtual enterprises – the 'when' and 'how'

"When to consider" an issue (issue – the "what" just discussed) of planning is not independent from the question of "how to decide". The crucial subject behind the "how" is ideally the desire to achieve integration by use of all relevant knowledge. It amounts to saying that the planner must be omniscient which of course is an impossible requirement, not least for a topic as complex as "planning for virtual enterprises". However, a sound systematic procedure to follow for deploying the "how" can help make sure that not only all relevant issues are dealt with at the right time, but also all important knowledge perspectives are incorporated as basis for decisions. In this respect GERAM helps on a general level because it proposes a carefully prepared structure and contents. This can be illustrated by examples – knowing quite well that not all components of GERAM have been used in deploying VERA in this short paper; therefore the full potential of VERA must be left to the reader to discover.

A change in the representation of a network's life history is appropriate in order to allow the presentation of an example. To the left in Figure 5 is shown the life history example from Figure 2 that contained one network entity, two VE entities, and one product entity. In the upper right corner this life history example is condensed into 4 lines as shown. This can be generalised as shown in the diagram in the lower right corner of Figure 5. This means that the life cycles numbered 1 to 4 (encircled) correspond to the life history example above and to the left. In the following this diagram will be used almost as a pictogram to depict a planned (i.e., a projected) life history of a VE-focused network.

Figure 6 in the centre shows this pictogram. The figure is used to describe some basics of a procedure for how to carry out the network concept phase.

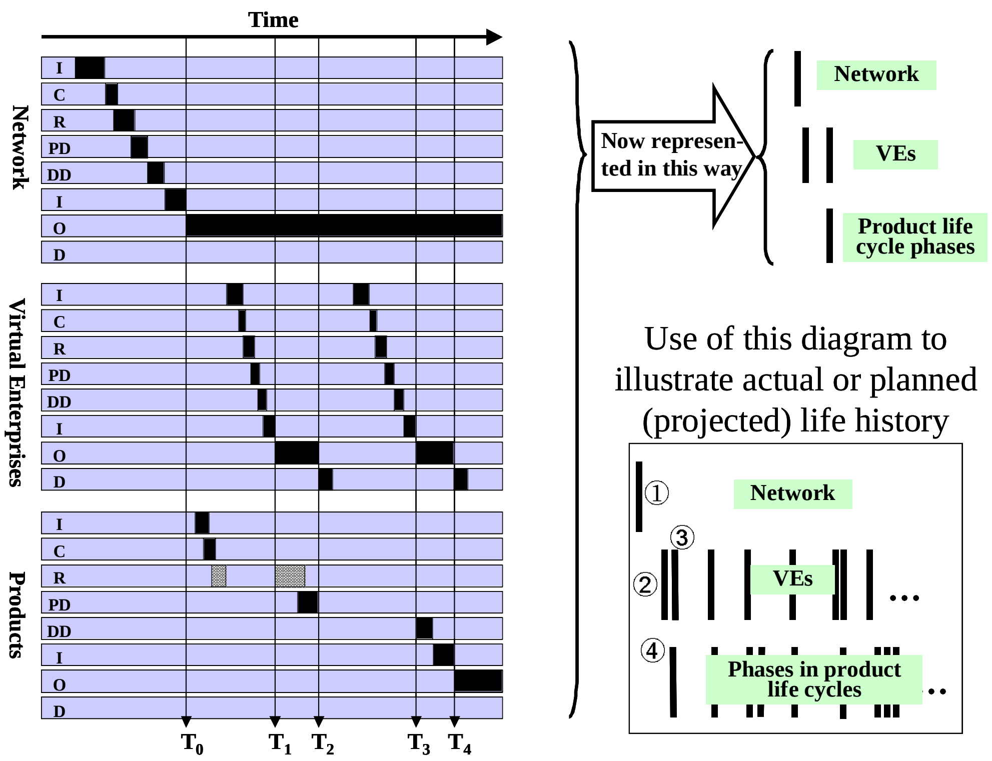

Figure 5: Change in life history representation.

The network concept phase constitutes a strategic planning activity that has to define the mission, basic operational concepts, policies etc. for a network. Strategic planning is usually an iterative activity, among other things comparing different possible development paths to ideal situations. In order to define an ideal "to-be"-situation, analyses often will take outset in market surveys and define potential competitive deliverables. A critical question is here: how much can be planned in advance, and to what degree is it possible to find or define commonalities between deliverables in order to secure reuse or repetitiveness in different ways – for instance by developing product models, service modules, or define common product platforms. These questions reflect the degree of preparedness for the network to aim at, and can constitute decisive elements of network operational concepts – among other things strongly influencing delivery times and quality. With the three dimensions of GERA in mind (i.e., life cycle phases, views, and genericity) a systematic analysis of expected deliverables (in the figure depicted as a hatching of some product life cycle phase activities) will help decide on these issues. For very important issues, it might be appropriate in the network concept phase to consider details of deliveries – compare the description of box 1 in Figure 3. In this example, as shown in Figure 6, three main types of deliverables have been identified: configuration, construction and maintenance deliverables. The figure also hints at a frequency of the different deliveries to be estimated and decided.

If we assume that the deliverables have to be produced by geographically dispersed VEs, the next step is to define concepts and strategies for the corresponding VEs. Again, as for the deliverables, more detailed analyses might be needed and a use of the three GERA dimensions can help to focus the analysis on the right topics. These could be: crucial technologies for VE formation (the resource view), crucial tasks for VEs (functional view), reference models for VEs (the partial level of the VE entity in VERA) as contract models (information view) or project models (function, information, organisation and maybe resource view) – compare box 2 in Figure 3. Again, it is important to define commonalities between the different VEs. Most of these questions relate to the extent of knowledge of already existing network partners or potential new partners. Many of the analyses and decisions might have to be performed together with network partners – or at least with different partner types in mind if future specific partners are not known.

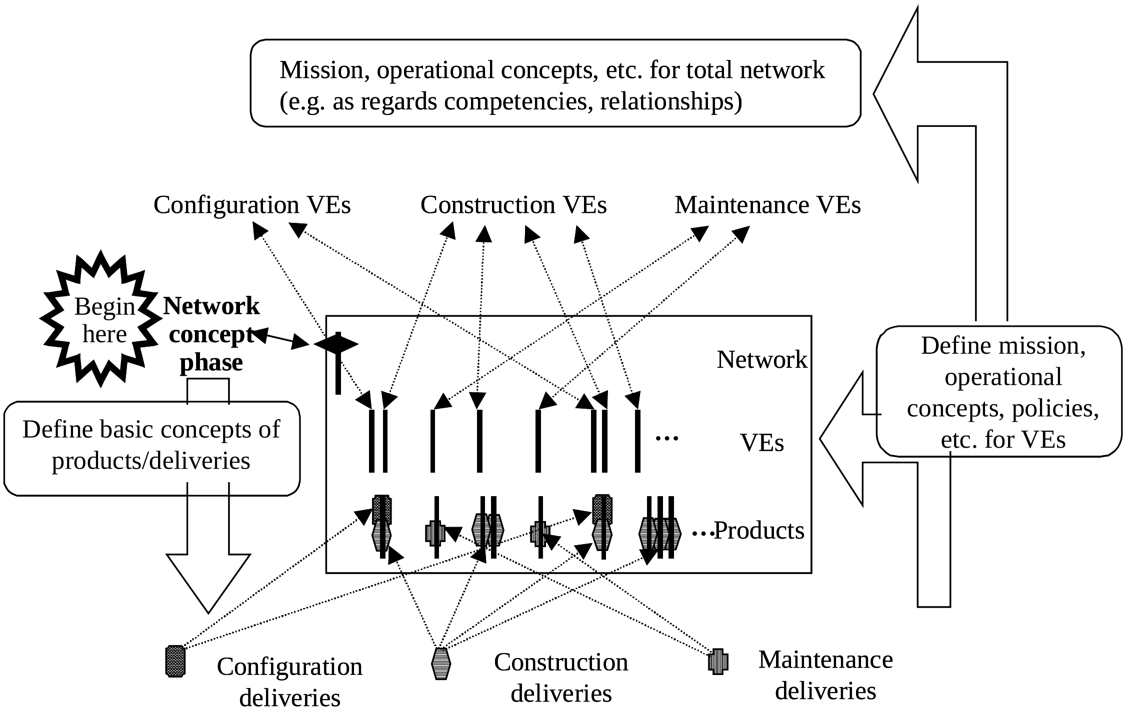

Figure 6: Example of network concept phase procedure.

All things considered these analyses result in a definition of network missions, operational concepts, etc., as a totality. Reference models for VE focused networks, as indicated by box 3 in Figure 3, not only could help define the final network concept, but also could be of help through the whole planning process as guiding principles. See [5] for more information on procedure and methodology.

3.3 VERA as an organising tool – more examples

Different industries are very different as regards to products, workflow, operational procedures, etc., and even for the same industry different traditions and concepts are used in different companies and countries. This is an important barrier to the exploitation of the potentials offered by ICT-supported cross-continental and cross-cultural project organisations, such as virtual enterprises. An agreed-upon architecture, such as VERA, in this context will not only help to frame what is discussed or negotiated, but also to organise the already existing body of knowledge as reference models including standards [4].

In the forerunner of GLOBEMEN, the Globeman21 project (Global Manufacturing in the 21st Century, [6]), VERA[3] was used to compare and analyse all industrial pilot projects [7]. It proved possible in this way to compare seemingly very different projects and as a consequence enable a general experience collection.

The dynamics of virtual enterprises have been emphasised by many writers in the field why reconfiguration has been proposed as an important phase in life cycle models of virtual enterprises. In [8] it is shown how reconfiguration, by use of VERA, proves to be either a part of the operational phase of a virtual enterprise as an already built-in flexibility, or proves to be a backflow into preceding phases of the virtual enterprise life cycle. In the last case VERA allows for an easy classification of different types of reconfiguration depending of how many life cycle phases are involved. Figure 7 illustrates the case.

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[3] In Globeman21 VERA was named VE Framework Model. In GLOBEMEN it was renamed in the process of creating VERAM.

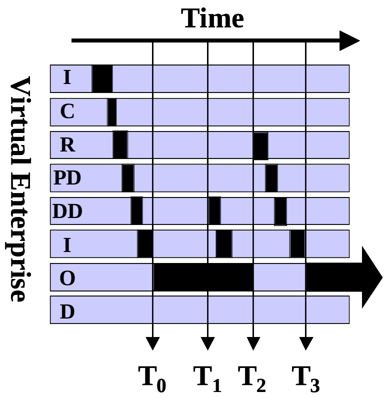

Figure 7: Examples of VE reconfigurations.

At T_0 a VE has been formed and goes into operation. At T_1 a reconfiguration need is discovered. In this case it implies only a minor redesign of the VE (a backflow into "Detail Design" and a corresponding "Implementation" of the design changes). Notice, that the VE does not need to stop its operation during the reconfiguration. The other shown example occurs at time T2, whereupon a more extensive change is required, resulting in a backflow into the "Requirements" phase and a simultaneous suspension of the VE operation. In this way VERA allows for us to develop a typology of reconfiguration. A consideration of reconfiguration might be an important aspect of the "what" and "when" questions already discussed. Paraphrased, what types and what degrees of flexibility should be prepared for when setting up a VE focused network or a specific VE?

4. Conclusion

Enterprises, not least in one-of-a-kind industries, face major challenges regarding a full exploitation of existing and future ICT potentials. Major keywords for the challenge are globalisation, outsourcing and customisation. The vision is a rapid formation of customer-focused and -tailored virtual enterprises together with partners from different continents and cultures. This demands a new global understanding, enabling a safe cross-company communication and negotiation in the preparation for and the order-triggered set-up of virtual enterprises. The Virtual Enterprise Reference Architecture (VERA) and the matching Methodology developed by GLOBEMEN show promise not only as a management tool to structure and guide in preparing for the challenge, but also as an organising tool to sort out and order already existing knowledge as, for example, reference models. This again will enable a cross-company and cross-industry sharing of experiences gained.

References

Note: references to non-GLOBEMEN literature can be found in listed publications.

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