INTERNATIONAL DESIGN CONFERENCE - DESIGN 2010
Dubrovnik - Croatia, May 17 - 20, 2010.

DESIGN 2010

A SYSTEMIC APPROACH TO DEFINE THE HIERARCHICAL STRUCTURE OF AN AIDED COMPETENCE MANAGEMENT SYSTEM FOR VIRTUAL TEAM BUILDING

M. Schumacher, J. Stal-Le Cardinal and J.Bocquet

Keywords: aided system, competence management, virtual team building, systemic approach, hierarchical tree

1. Introduction

The nature of teams has changed significantly because of changes in organizations and the nature of the work they do. As organizations face increasing global competition, mass customization, reduced product life cycles and the need to respond in time to customer requirements, they have introduced virtual teams to manage the New Product Development (NPD) process across temporal, geographic and disciplinary boundaries. In this work we bring the focus on virtual design project teams in the domain of NPD. Many authors have provided their own definition of virtual teams and the concept of virtual team lacks a universally accepted definition [Griffith 2003, Schmidt et al., 2001, Hart and McLeod 2003, Rezgui 2007]. In this work we consider virtual teams as teams that consist of Individuals that are geographically and temporally dispersed and act interdependently through technology to achieve a common goal.

As Virtual Teams are considered as the crux of 21st century organizations [McDonough et al., 2001] their increasing use composes a major challenge to the human resource management, particularly in terms of competence management [Pauleen, 2002].

According to Harzallah and Vernadat (1999), one of the major benefits of a competence management system for virtual teams is that Individuals can be assigned with specific jobs or tasks. Competence assignment is invaluable in the field of NPD that comprises numerous knowledge intensive tasks, and thus the need for highly skilled employees. We refer to North (2002) who declaims that competencies are substantiated in the moment of knowledge application, which means that competencies only exist when knowledge meets a task. Accordingly, we speak of competence in the context of interpreted knowledge that is contextualized by an individual or a group that confers an aptitude of decision to a respective action [Bocquet and Stal-Le Cardinal 2005].

Broadly speaking, competence management includes identification, acquisition, development, distribution, preservation and use of competencies and is the way in which organizations manage the competencies on an organizational level, team level and the level of individuals [Schumacher et al. 2008b]. In our research we are essentially focusing on gaps between existing competencies and required competencies for current or future needs. In this case, competence management occurs in the moment where a task and its required competencies are assigned to an Individual and his acquired competencies [Schumacher et al. 2008b].

The long term objective of our work is to provide a generic **Aided C**ompetence **M**anagement for **V**irtual **T**eam **B**uilding **System** (Aided CMVTB System) that permits an adaptation not only to organizations but also to design projects without a real organizational structure, that is to say no physical existence. This system should handle competencies in a virtual environment and should be adaptable to each specific organizational context. We aim to provide a competence management method for aided virtual team building whose competencies match the best to the requirements of design projects, or by providing competencies that match the best with a specific task to improve the NPD process. Due to our research objective to take into account and model interdependencies between the domains of virtual teams and competence management a systemic approach has been used as it has already shown its efficiency in these types of research (Le Moinge, 1999). According to the systemic approach the domains of virtual teams and competence management are considered as systems that are in interrelation with our Aided CMVTB System. An overview of our positioning is shown in figure 1.

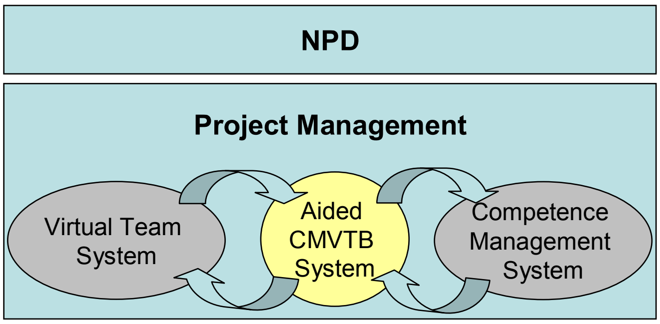

Figure 1. Positioning of the Aided CMVTB System

It handles the domain of NPD as the context and the aspect of Project Management as the kind of organization of our work. Our Aided CMVTB System is in interaction with the Virtual Team System and the Competence Management System. The Aided CMVTB System functions as method that supports the Virtual Team System to create virtual teams and the Competence Management System to give recommendations. On the other hand the experience of the Virtual Team System and the Competence Management System can enhance the Aided CMVTB System by giving also recommendations. Our focus is set on the Aided CMVTB System that supports the Virtual Team System by giving best practices, guidelines and recommendations for competence management for virtual team building.

The main objective of this work is to get detailed information about the Aided CMVTB System by providing a hierarchical form of the sum of the functions that describe it. We don't intend to give detailed characteristics of competence management for virtual team building but compass to take a systemic regard to describe the Aided CMVTB System by functions that are visualized in a hierarchical form. This gives insights about the needs and requirements. Our approach is based on the functional analysis [Le Moigne 1999]. Its approach is presented in the following section.

2. Systemic Approach

The functional analysis is the tool that we use to be as objective, generic and exhaustive as possible. It helps us to understand the complexity of the Aided CMVTB System from a systemic point of view. We decided to use the systemic approach of the functional analysis because its power lies in its ability to identify needs and requirements, show interrelations and apply a united symbolism and theory to deal with the important central features of the topic [Snodgrass 1986, Schumacher et al. 2008a]. According to the systemic approach the method of competence management for virtual team building is considered as a system that is described by functions [Yosida, 1978]. In our previous work we presented the steps of identifying and describing all the functions of the Aided CMVTB System [Schumacher et al. 2008a]. This study focuses on the last step of the functional analysis, the hierarchical tree, which facilitates the characterization of those functions. The tree structure provides a clear visibility of the large number of functions making up the system. It helps us to measure the importance of the functions in a qualitative way and to represent the system in a hierarchical form. The analysis is to control the distribution and maintenance of these functions in a systematic and useful manner.

The focus of this work is set on the characterization of the functions that helps to classify the sum of the functions that describe the Aided CMVTB System in a hierarchical form. This hierarchical form helps to provide a model that is adaptable at each specific context.
The steps and output of the functional analysis are shown in figure 2.

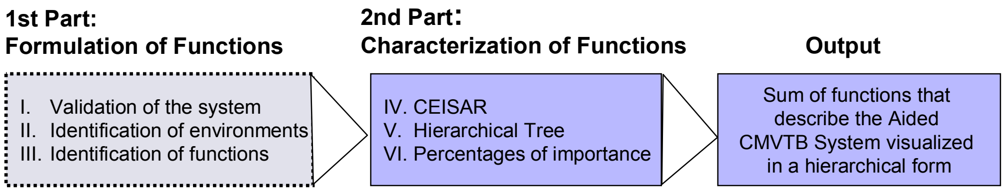

Figure 2. Steps and Output of the Functional Analysis

As the focus of this work is set on the second part of the functional analysis, the characterization of functions, we are going to present only briefly the results of the first part in this section. The results of the second part will be presented more in detail in the following section.
In the first part of our study that concentrates on the formulation of functions (Schumacher et al. 2008a) the approach of the functional analysis provided us following key findings. In step I., the "validation of the system," we got a first impression about the system itself, its target group, application areas and limits, as well as the reason for its existence and its intention. We identified that its target groups are design projects, service providers, clients and end users. The reason for existence of our system is the need to react on the growing complexity of engineering tasks and the improvements in the NPD and project management process. The system's intention is to provide a method that intends to improve the NPD process by providing a virtual team whose competencies assign the best to the requirements of design projects.
We passed a validity control and analyzed the cause of the system, the objectives it aims for, and the risks of evolution or disappearance of the need. In step II., the identification of environments, we defined 10 main environments and 43 sub-environments. This step was done in a multi-disciplinary brainstorming process based on the literature review. The defined environments permit us to take different concepts, critical terms and conditions into consideration. They are shown on the left side of following figure 3.

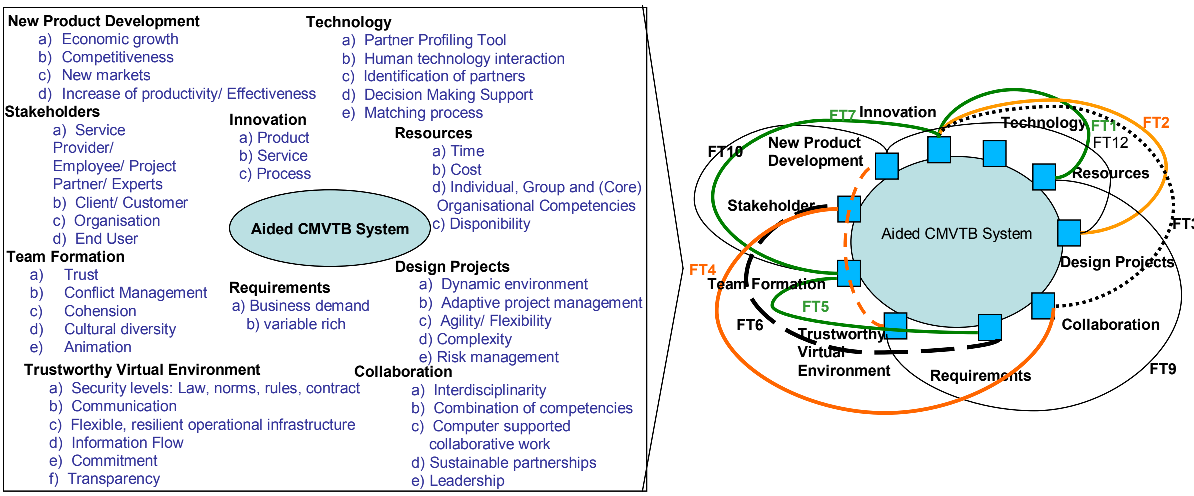

Figure 3. Environments and Extract of Interfaces according to the Aided CMVTB System

In step III., identification of functions, we established interfaces between those environments. According to Snodgrass each component of an open and living system interacts constantly with its environment [Snodgrass 1986]. This means that it is not enough to take only the system itself into account, but the whole interaction between the system and its environments. This fosters to get a holistic picture of all decisive components that have an important impact on our Aided CMVTB System. By putting the different environments of our system in relation we are going to provide the functions that describe our Aided CMVTB System. Those functions describe the optimum behavior of the system and its terms of usability. An extract of interfaces to provide functions is seen on the right side of figure 3. In order to get a structure in the analysed environments we clustered them although the different levels have no impact on the importance of the respective environment. Clusters represent the main elements that have been identified. Sub-clusters were built whenever similar specifications were seen and family groups could be built. In visual terms, the sub-clusters are not listed on the right side of figure 3 but they interact with other sub-clusters or main clusters in the same way as main clusters do.

There are two kinds of functions: the transfer functions (FT) which are at least two different environments that interact by the means of the system, and the constraint functions (FC) which are generated by only one environment and that the system has to respect absolutely [Apte 2000]. We identified 243 transfer functions and 38 constraint functions.

An example of those functions that have been detected is shown in the following listing.

- FT18 -The system should assign **resources** like time, cost, personal and disponibilities to specific requirements of **design projects**.
- FT28 -The system should provide that **technology** fosters **communication** among team members.

In a collaborative negotiation process key functions were defined that represent main aspects of the system.

The focus of this work lays on the characterization of the functions. In the second part of the functional analysis, identified key functions are characterized in terms of their importance due to the specific needs of a respective designn project. In order to address the relative importance of the architecture, we use the CEISAR Enterprise Architecture Cube as an evaluation and positioning framework. By referring to the model of the CEISAR we intend to present a first structure of the functions that build the hierarchical tree in step IV. To determine the different basic categories of the highest level of the hierarchical tree we lean the model of the CEISAR Enterprise Architecture Cube and its respective eight dimensions. The tree structure is presented in step V. It provides a clear visibility of the large number of functions making up the system. It helps us to measure the importance of the functions in step VI. in a qualitative way and to represent the system in a hierarchical form. The respective results of the second part of the study will be presented in detail in the following section.

3. Results: Characterization of the functions

The approach of CEISAR focuses on “Enterprise Architecture” and tries to support organizations to develop their adaptivity in a proactive way. According to Weill et al. (2006) Enterprise Architecture provides an organizing structure for business processes and IT infrastructure that reflect organizations’ operating model by integration and standardization of their requirements. According to CEISAR, Enterprise Architecture is seen as a new discipline that restructures systems and aligns them to the business strategy to accelerate transformation [CEISAR 2008]. The primary purpose of describing the architecture of an enterprise is to improve the effectiveness and efficiency of the structure itself. As virtual teams consist of actors in a virtual environment that is considered by us in an abstract way as virtual enterprise we use the CEISAR Enterprise Architecture Cube as framework that is easily adaptable to our system. We consider that building a virtual team implies the same structures of business processes and IT infrastructure that reflect an enterprise in its operating model by integration and standardization of their requirements.

Referring to the CEISAR Enterprise Architecture Cube we analyze the architecture of the Aided CMVTB System. According to our systemic approach the CEISAR Enterprise Architecture Cube builds, as an evaluating and positioning framework, the fundament of the hierarchical tree. We take into account the different dimensions of the cube to structure the functions that define the Aided CMVTB System.

The CEISAR Enterprise Architecture considers three main concerns of one organization in order to develop an adequate architecture: Complexity, Agility, and Synergy. These are the key business concerns of each organization and according to CEISAR the most important challenges. As those three dimensions are crucial for architecture developing we adapted a set of aspects for our evaluation. The three main concerns comprise referring to CEISAR already aspects as: Strategy, Human Resources, Communication, Globalization, Productivity, and Marketing. Furthermore, we added six own aspects due to the literature research according to the Aided CMVTB System: Simplicity of Use, Innovation, Universality, Costs, Quality and Technology. They are used to build a second structure of the hierarchical tree. Figure 4 shows the aspects of the CEISAR Enterprise Architecture Cube due to the Aided CMVTB System.

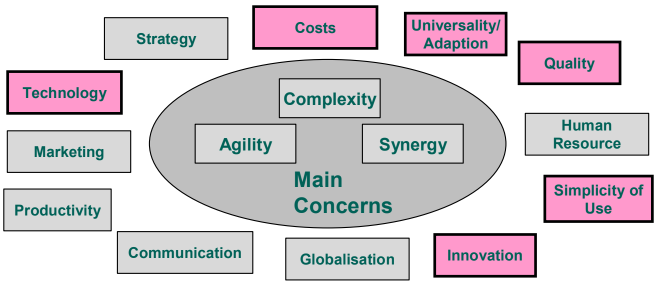

Figure 4. Aspects of the CEISAR Enterprise Architecture Cube due to the Aided CMVTB System

Each of the three main concerns Complexity, Agility and Synergy is regarded from two different perspectives that define the content. Concerning Complexity CEISAR makes the difference between "real world execution" and "model". By separating the real world execution from the global model CEISAR tries to master the complexity. By focusing on global maps of processes, solutions, functions, services, and entities this global model helps to understand the complexity of an organization and how the organization works.
Concerning Agilty the two perspectives are "transformations" and "operations". Synergy considers "sharable or reused elements" and "specific elements.
As result of these three main concerns which are each split in two denominations, we obtain eight different dimensions that form the CEISAR Enterprise Architecture Cube. It is presented in figure 5.

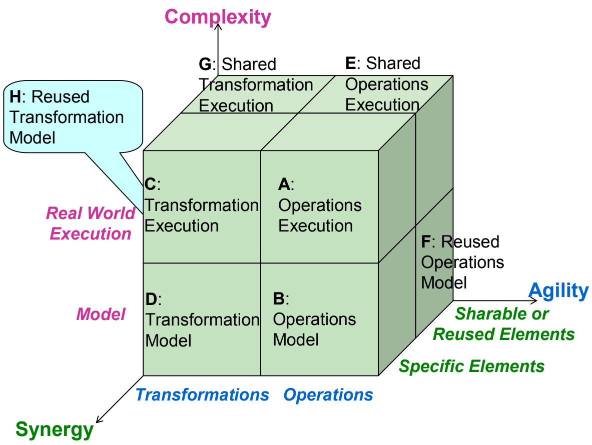

Figure 5. CEISAR Enterprise Architecture Cube

In our study we aim to translate the eight dimensions of the cube to our main functions that are concerned by them.
To give consideration in a holistic way to the concept of the CEISAR Enterprise Architecture Cube we incorporated its eight dimensions in our hierarchical tree and adapted them to the Aided CMVTB System and its corresponding functions.
While dimension A "Operations Execution" stands for operations and actions in the real world and focuses on the operations that are done in an organization, dimension B "Operations Model" regards the way organizations are doing those operations. We adapted dimension A to our functions with the focus "What do I do". Dimension B is translated to our functions in terms of "How do I do".

Dimension C “Transformation Execution” considers the execution of the real world to evolve the way of doing. Due to pure functions we are focusing on the question “What makes me evolving the model to integrate the evolution”. Dimension D “Transformation Model” takes the question of “How I make evolving the model to integrate the evolution?” into account. While Dimension E examines sharable elements of the execution and focuses on “What do I share with others” is dimension F “Reused Operations Model” concerned in our translation by the generalization and the forming of the model. “Shared and Transformation Execution” looks at transformations of the real world execution to “explain and form how to make evolving”. The last dimension H “Reused Transformation Model” contemplates “How do I explain how to make evolving”. Figure 6 shows the results of the translation to the functions due to the Aided CMVTB System.

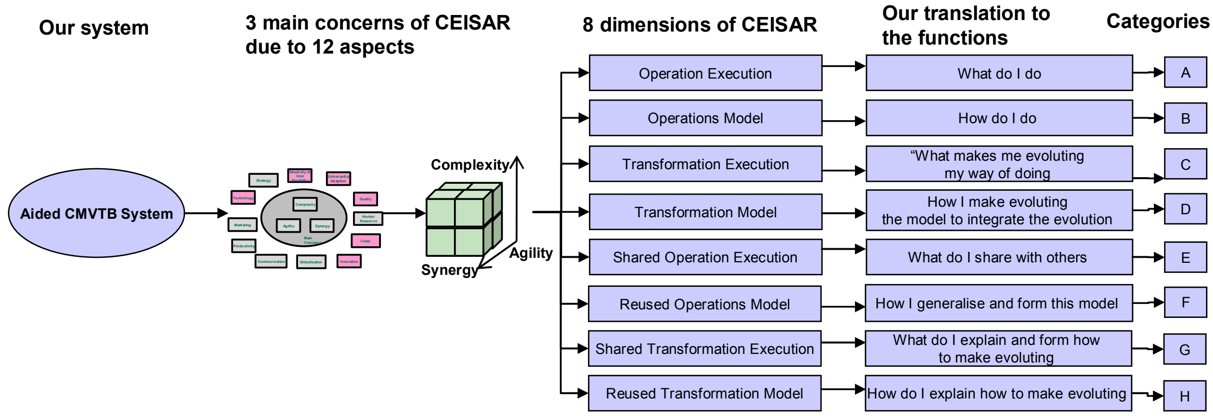

Figure 6. Basis of the hierarchical tree according to the Aided CMVTB System

That generic representation of an entire organization allowed us to translate the three main concerns Complexity, Agility and Synergy its respective eight dimensions to our functions and to use them as first structure of the hierarchical tree. In order to facilitate the visuality we neglect the intermediate step of the CEISAR Enterprise Architecture Cube and the translation to the functions. In further figures only categories A – H will be illustrated.

We intend to use our translation of the eight dimensions of the CEISAR Enterprise Architecture Cube as a first structure to establish different categories of the highest top level of the hierarchical tree based on their expression similarity. The second structure is based on the presented aspects in figure 4. The structure is reflected as distinct branches and constructs the hierarchical tree. It starts at a top level with a high importance and breaks down the functions to lower levels due to different branches. A function, which is passed to a lower level, is a higher level function for the recipient level. With the breaking-down in lower levels also the importance of the respective functions gets lower. In the first step we defined the top level functions and decompose them to lower level functions. A function of a lower level can be required by a number of main functions which means that it may appear several times in the hierarchical tree.

Figure 7 gives a brief extract the branch A “What do I do” and the branch B “How do I do” of the hierarchical tree due to the Aided CMVTB System. The figure presents exclusively branch A and branch B for reasons of visualization. Furthermore it shows only the first structure according to the eight dimensions of CEISAR and the second structure according to its aspects as well as the first and second level of functions. It is self evident that the functions are broken down to several levels. Only in one example, the beforehand presented function FT18, the figures breaks the functions down up to the fourth level.

While the beforehand presented function FT18 is situated in the first level of the branch B, function FT28 is on the second level of branch A. As a second structure we implemented the aspects Marketing, Human Resource, Quality, Innovation and Technology etc. due to the main concerns of the CEISAR Enterprise Architecture Cube presented in figure 4. This permits us to get more information about each respective branch and it helps us to structure the functions from a second perspective.

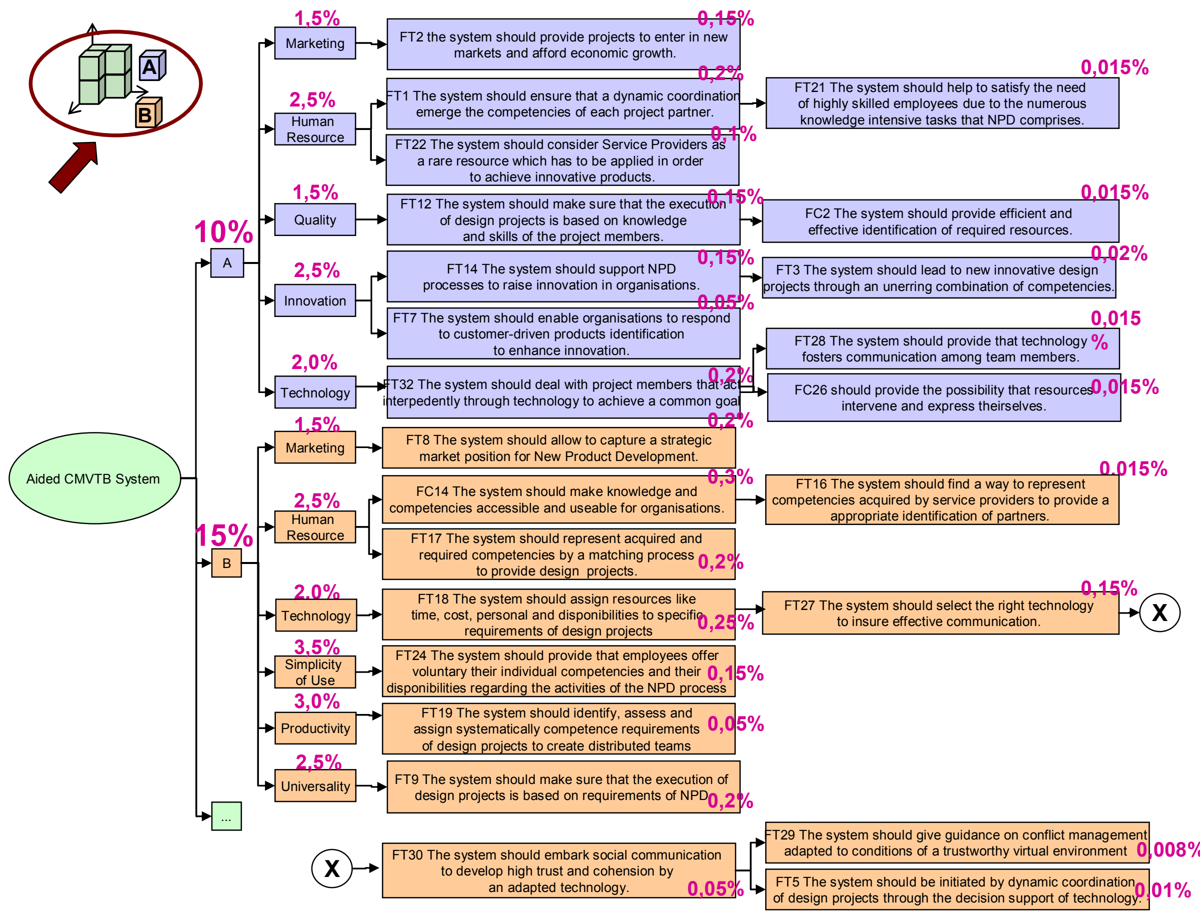

Figure 7. Extract of Branch A "What do I do" and Branch B "How do I do" of the hierarchical tree according to the Aided CMVTB System

The importance of the hierarchical tree is derived and translated into percentages while building the project team. The hierarchy of the function is determined while the percentages are flexible. They depend on the purpose of the specific needs. In figure 7 the percentages are noted as examples. In general, they are defined during the constitution of the virtual team depending on its specific needs. The fact that the hierarchy of the functions is fixed allows us to say that the importance of the functions decrease from the left to right with each lower level. This gives us insights about their importance even if the percentages of importance are just noted as examples this figure. Functions may appear several times in different branches or levels due to their respective interdependencies with other functions.

Both of our beforehand presented functions FT18 and FT28 are classified within the aspect of Technology. But nevertheless they are positioned in different branches and different levels what implicates different importance. In our example FT18 is in the first level with fixed 0,25%. FT28 is situated in the second level with 0,015%.

4. Conclusion

The generic aspect of our Aided CMVTB System is based on the flexibility of our model. Any priorities to which a stakeholder might aspire, the model is adaptable to the respective demands.

Based on the systemic approach of the functional analysis we provided a holistic picture of all decisive components that have an important impact on our Aided CMVTB System. We described all functions of our system that reflect requirements and ensured that they are structured in an appropriate manner. We were as objective, generic and exhaustive as possible. We identified interrelations and a hierarchical structure among these functions. The hierarchical tree allows the functions to be regrouped and their traceability. The hierarchical structure starting at a top level working down in

detail allowed verification that the functions of the lower levels are consistent with functions of this top level. It helped to regroup the functions and to establish interrelations between functions.
Predicated on the CEISAR Enterprise Architecture Cube the hierarchical tree is one of the most important reasons for the generality of the Aided CMVTB System.
The fact of having defined a structure of importance permits that the Aided CMVTB System is applicable to a wide range of organizations in the domain of NPD. It can apply to various application domains and to different design projects, with the weighting in terms of percentages varying according to the point of view of the stakeholder. The flexibility of varying the percentages permits us to provide a global Aided CMVTB System that is adaptable to each context by pointing out different specific categories and aspects.
Table 1 presents different possible scenarios that constitute theirselves by crossing the different priorities of stakeholders due to the hierarchical tree, regarding the branches or the aspects.

Table 1. Extract of the generic model presented as probable scenarios

	Scenario	a)	m+1)
	Aspects / **Branches**	All (1-12)	Focus: Aspect m+… m+1
1)	All (A-H)	1 a)	1 m+1)
n+1)	Focus: Branch n+… n+1	n+1 a)	n+1 m+1)

The ability of our Aided CMVTB System to adapt its point of view on the needs of the stakeholder constitutes the generic aspect of our model. The focus of scenario 1a) is set on the entire hierarchical tree that includes all the branches A-H and keeps the whole CEISAR Enterprise Architecture Cube in mind. At the same time it considers the entire aspects of the second cluster of the hierarchical tree. Priorities of the stakeholders are set by percentages. Scenario n+1a) centers on specific branches. It takes into account that there might be different priorities concerning the different branches of the hierarchical tree due to the degree of maturity of the CEISAR Enterprise Architecture Cube. There might be a stakeholder that stresses three branches - branch A “What do I do”, B “How do I do” and D “How I make evolving the model to integrate the evolution” or another one that focus only on one branch A “What do I do”. The variations are flexible and depend on the need of the respective organization or design project.
From the point of view of the second cluster, the aspects, we distinguish additionally a focus on the composition of the branches. The presented aspects that constitute the three main concerns Complexity, Agility and Synergy of the CEISAR Enterprise Architecture Cube describe each respective branch in detail. As only an assortment of aspects is considered in each respective branch, they characterize the composition of them. Scenario 1 m+1) focus on the entire hierarchical tree, but it considers just some chosen aspects. Scenario n+1 m+1) considers a choice of branches due to some chosen aspects. In our presented example in figure 7 this might be branch A and B under the aspect of Technology.
The flexibility of utilization of our Aided CMVTB System allows us to provide a generic model that is adaptable to each context. By being able to point out different specific aspects the Aided CMVTB System is applicable to the needs of different stakeholder.

5. Future Research Directions

In further research we will determine our research to provide an Aided CMVTB System. In this work we have defined functions and structured them hierarchically to build with the help of the hierarchical tree a framework of our system. The CEISAR Enterprise Architecture Cube helped us in a first step to structure the functions that define the Aided CMVTB System. In a second step it will be used as an evaluation framework. We take into account the different dimension of the cube to evaluate the exhaustion of the functions that define the Aided CMVTB System.

In the further step the detected functions should be realized and translated in applicable solutions that could be implemented in the industrial practice. We use the tool of the House of Quality that helps us to find existing concepts and techniques of competence management and virtual team building to realize the key functions. This tool permits to use the fixed importance of the hierarchical tree as fundamental input and to translate the key functions in applicable solution (Schumacher et al. 2009). On the one hand, this helps to find out strengths and weaknesses of the existent concepts and techniques due to the demand of the functions that could be adapted easily to our Aided CMVTB System. On the other hand, through this approach we get information about those functions whose demands are apparently difficult to achieve. Functions that are not satisfied because there are solutions missing in the literature are treated with specific attention. It is up to us to propose concepts and techniques that answer as quality characteristics to the need of the customer requirements.

To be as inclusive as possible we aim to provide an interrogation platform where concepts and techniques of already well-developed methodologies could be consolidated. One of our near-term objectives is to conduct interviews with possible users and experts to validate the hierarchy of our key functions. This will help to will to master the complexity of the system and to apply our theoretical approach to the industrial practise. In a second steps we will interrogate those experts about practical concepts and techniques that answer to the needs of the theoretical functions. Those concepts and techniques will be an essential part of our Aided CMVTB System. They give best practises and recommendations how to build a virtual team under consideration of Competence Management that can be easily adapted in the industrial reality.

We are in collaboration with the Centre Francilien d'Innovation of Paris to apply in a further step the Aided CMVTB System to the industrial reality and especially to innovative organizations in the domain of new services, processes or product development.

References

Apte,"La Méthode APTE" (®) d'AV/AF, Petrelle, 2000.

Bocquet, J.-C., & Stal-Le Cardinal, J., "Definitions and temporal positioning of concepts linked to decision making in industrial project design- DIKCORAC", International Conference on Engineering Design, ICED 05, Melbourne, 2005.

Ceisar, ECP - Center of Excellence in Enterprise Architecture, White Paper, Business Process Modeling, April 2008, www.ceisar.org, dated: 04/12/2009.

Ceisar, ECP - Center of Excellence in Enterprise Architecture, White Paper, Enterprise Modelling, April 2008, www.ceisar.org, dated: 04/12/2009.

Griffith, T. L., Sawyer, J. E., & Neale, M.A., "Virtualness and Knowledge in Teams: Managing the Love Triangle in Organizations, Individuals, and Information technology", MIS Quarterly, no.27, 2003, pp. 265-287.

Hart, K. H., & McLeod, P.L, "Rethinking Team Building in Geographically Dispersed Teams: One Message at a Time", Organizational Dynamics, Volume 31, Issue 4, January 2003, pp. 352-361.

Harzallah, M., & Vernadat, F., "Human resource competency management in enterprise engineering", in: 14th IFAC World Congress of Information Control in Manufacturing, Beijing, China, 1999. Le Moigne, J.L. "La modélisation des systèmes complexes", Dunod, 1999.

Mc Donaugh, E., Kahn, K. & Barczak, G., "An investigation of the use of global, virtual, and co-located new product development teams", Journal of Product Innovation Management 18 2, 2001, pp. 110–120.

North, K., "Wissensorientierte Unternehmensführung - Wertschöpfung durch Wissen", Gabler Verlag, Wiesbaden, 3. Ed., 2001.

Pauleen, D. "Leadership in a global virtual team: An action learning approach", Leadership and Organization Development Journal 24 3, 2002.

Rezgui, Y., "Exploring virtual team-working effectiveness in the construction sector, Interacting with Computers 19, 2007, pp. 96–112.

Schumacher, M., Stal-Le Cardinal, J. & Mekhilef, M., "A competence management methodology for virtual teams – A systemic approach to support innovation processes in SME's", International Design Conference – Design 2008, Dubrovnik, May 2008a.

Schumacher, M., Stal-Le Cardinal, J., & Mekhilef, M., "Competence management for virtual team building: A survey", International Conference on Integrated, Virtual and Interactive Engineering for fostering Industrial Innovation - IDMME 2008, Peking, October 2008b.

Schumacher, M., Stal-Le Cardinal, J., & Bocquet, J.C., "Towards a methodology for managing competencies in virtual teams – A systemic approach", in: Camarinha-Matos, L.M., Paraskasis, I., & Afsarmanesh, H. (Eds.): Levering Knowledge for Innovation in Collaborative Networks, Springer Berlin, Heidelberg, New York, 2009, pp. 235- 244.
Schmidt, J.B., Montoya-Weiss, M.M., & Massey, A.P., "New Product Development Decision-Making Effectivness: Comparing Individuals, Face-To-Face Teams, and Virtual Teams, Decision Science", Volume 32, Number 4, 2001.
Snodgrass, T.J., " Function Analysis – The Stepping Stones to Good Value", CVS at KASI; Muthiah, CVS, 1986.
Weill, P., Ross, J. W., & Robertson D.C. , "Enterprise Architecture as a Strategy", Boston, Massachusetts: Harvard Business School Press, 2006.
Yosida, K., "Functional analysis", 5th ed., Springer-Verlag, Berlin, Heidelberg, 1978.

Marinita Schumacher
Ecole Centrale Paris
Industrial Engineering Department
Grande Voie des Vignes
Châtenay Malabry Cedex, France
Telephone: +33 141131807
Telefax: +33 141131272
Email: Marinita.Schumacher@ecp.fr