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# MANAGEMENT OF DIFFERENT TYPES OF CONFIGURATION KNOWLEDGE WITH THE K- & V-MATRIX AND WIKI

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## 1. Knowledge Management, Product Design and SMEs

Although *knowledge management* (KM) is currently a buzzword, it is not a big topic in small and medium sized enterprises (SMEs). The need for KM in SMEs is not as big as in large organisations. Small size and good working conditions provide a lot of the basic requirements for good KM without having to care about it [Radermacher 2001]. However, some of the tools associated with KM would still be useful for SMEs. But unfortunately, most of the KM-tools are conceived for large organizations and hard to implement in SMEs, where lightweight, "plug-and-play" solutions are needed.
An area with a lot of potential for KM is Product Design [Beitz et al. 1997]. Product design knowledge is bound to people and thus staff fluctuation mostly leads to a dramatic loss of knowledge, especially in SMEs, where the product design departments often consist of only few people. Before presenting our approach to improve this situation, we will introduce a classification of knowledge ressources in product design (see figure 1).

## 2. Classification of the Knowledge in Product Design

As indicated in figure 1, the knowledge ressources are stored in the *Digital Product* (see [Leonhardt 2001]) and can be classified in three groups. The two groups *Product Documentation* and *Design Project Related Information* are commonly accepted as important and most of it is managed in an appropriate way. However, some of the knowledge ressources in figure 1 – especially the group *Experiences* - are not managed very well, partly because of unawareness of their importance and partly because of the absence of powerful methods and tools to manage them [Beitz et al. 1997].

### 2.1 Configuration Knowledge as Part of Experiences or Product Documentation

An important knowledge ressource is what we call *configuration knowledge*. It mainly consists of the knowledge needed to configure a variant product according to customer requirements and the restrictions given by the product itself. Thus, configuration knowledge is e.g. knowledge about the possible variants of a product and the customer requirements that can be fulfilled with them. Depending on company, product, quantity produced etc. we can consider configuration knowledge either part of two groups in figure 1:

- *Product documentation*: E.g. in a company selling a *modular system* (according to [Pahl, Beitz 1996]), which is “assembled-to-order”. Within that modular system, the necessary modules are just combined in a way that they fulfill the customer requirements. The configuration knowledge consists of the knowledge required to do this. In this case we consider the

configuration knowledge part of the product documentation, since it is bound to a certain modular system.

- *Experiences*: E.g. in a design department focussing mainly on *variant designs* (according to [Pahl, Beitz 1996]), the configuration knowledge is not bound to a certain product, but contains general knowledge about how to proceed designing a product, what to do and what not to do in certain cases.

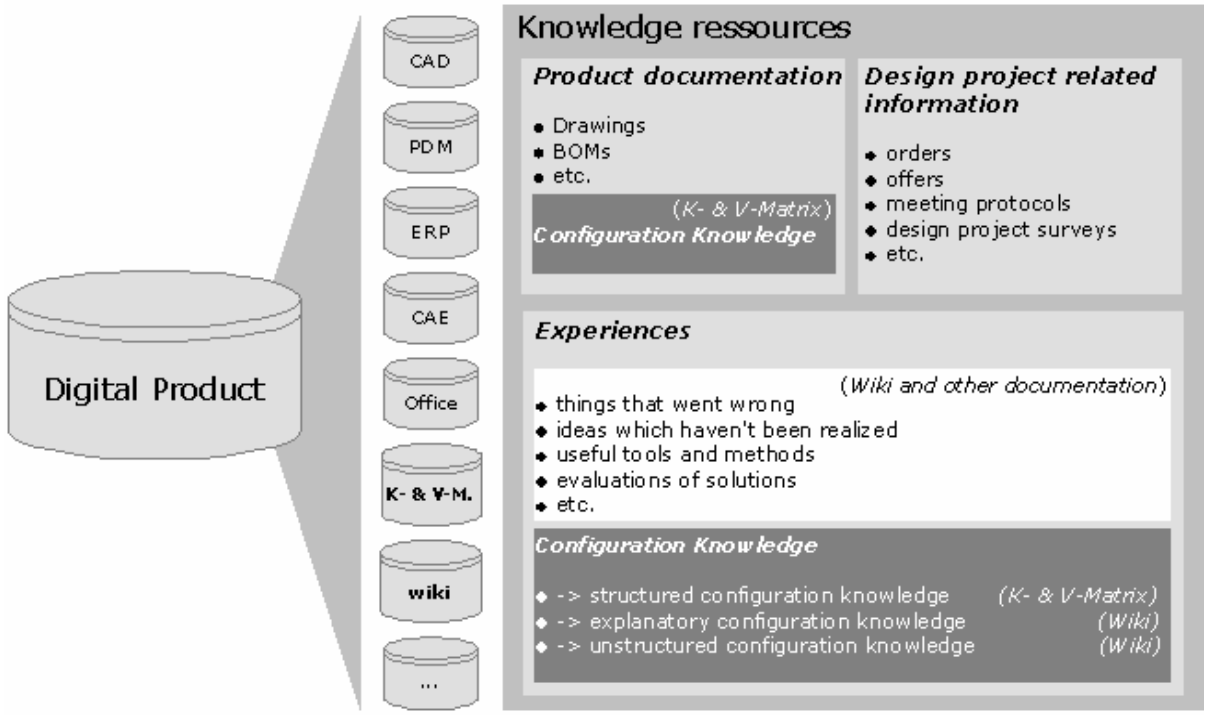


**Figure 1. Knowledge ressources in product design (partly based on [Beitz et al., 1997])**

### 2.2 Requirements for New Tools to Manage Product Design Knowledge

There are various requirements for new methods and tools for managing knowledge in product design in SMEs, arising from

- the special situation in SMEs concerning personnel, culture and infrastructure,
- the special needs and wishes of product designers.

The most important requirements can be summarized as follows:

- easy to use, fast to implement,
- low hard- and software requirements ("lightweight" applications),
- integration with other knowledge ressources - especially the ones already existing.

## 3 The K- & V-Matrix as a Method to describe Configuration Knowledge

Based on the requirements described above, the *K- & V-Matrix* has been developed at the Product Design Centre at the ETH Zürich as a method to describe configuration knowledge. The K- & V-Matrix is based on three matrices and describes

- the *technical view* of a product,
- the *customer view* of a product,
- the *mapping* between these two views and
- the *compatibilities* between properties of the technical and the customer view,

as indicated in figure 2. With this information, the product can be analysed and more information about the product can be gained. For a detailed description of the method, see [Bongulielmi et al. 2001] and [Puls et al. 2001].

In order to support the K- & V-Matrix method and to make its knowledge available for an online configuration, the *K- & V-Matrix system* has been developed. It consists of three elements (see on the right hand side of figure 5):

- an *editing tool*, based on the K- & V-Matrix method, used to describe the knowledge,
- a *data model* to store this data and
- a *query tool*, to query the data when configuring a product, e.g. during the sales process.

Both, the editing tool and the query tool, are web-based and easy to use. Combined with the K- & V-Matrix system, the K- & V-Matrix method represents a powerful tool to manage configuration knowledge. It is characterized by its ease of use and - compared to other description languages - fast results ([Bongulielmi et al. 2001] and [Puls et al. 2001]).

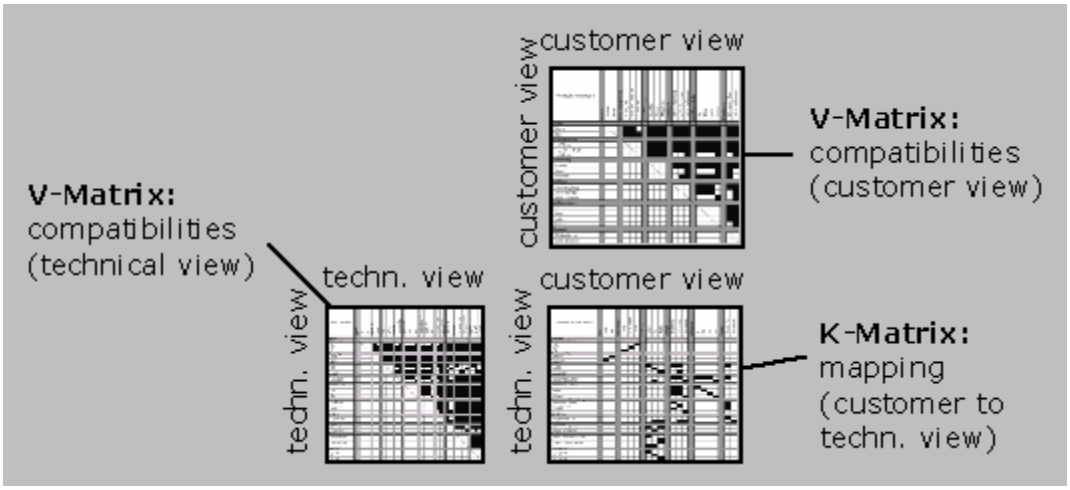


**Figure 2. The structure of the K- & V-Matrix**

### 3.1 Limits of the K- & V-Matrix

Since the K- & V-Matrix is very structured or "narrow minded", there is still configuration knowledge which cannot be described with it. This might be e.g. because it is too complex. After all, the ease of use comes along with some disadvantages and the biggest of them might be the inability to model very complex relationships between customer and technical view, see [Bongulielmi et al. 2001] and [Puls et al. 2001].

We can identify the following knowledge ressources for which appropriate ways for describing them must be found:

- As configuration knowledge (see figure 1):
  - Explanatory configuration knowledge. E.g. knowledge like "What does this product property exactly mean?" or "Why are these two product properties not compatible?".
  - Unstructured configuration knowledge which is not - or not yet - structured enough to "fit" into the K- & V-Matrix. This knowledge occurs e.g. during the knowledge acquisition process and will eventually evolve into the more structured configuration knowledge contained in the K- & V-Matrix or into the explanatory configuration knowledge mentioned above.
- The general Experiences in figure 1.

So, a tool for describing these knowledge ressources must be found which

- integrates with the K- & V-Matrix
- integrates with other knowledge ressources in figure 1 and
- fulfills the "Requirements For New Tools and Methods" mentioned above.

## 4. Wiki as an Add-on to the K- & V-Matrix

In order to overcome the limits of the K- & V-Matrix, the "Wiki" system has been chosen to complement the K- & V-Matrix.

### 4.1 Wiki as a Discussion and Collaboration Server

“Wiki” stands for "quick, fast, speedy" in Hawaiian and also for a *Discussion and Collaboration Server* with a strength in rapidly collecting and cross-referencing information. As [Leuf, Cunningham 2001] put it, Wiki is a "software tool that promotes and mediates discussion and joint working between different users". Working together on a wiki is like creating a "collaborative Website" [Leuf, Cunningham 2001] and doing that, more and more easily accessible and searchable knowledge is created. In addition to that, this explicit knowledge is quite structured and cross-referenced.
Although Wiki is not very wide-spread in industry, there are still many organisations and individuals using it as a discussion server or as knowledge bases (see [Leuf, Cunningham 2001]).


**Figure 3. Example of a customized Wiki page**

### 4.2 The Wiki Concept

So what's the concept of Wiki and what are the functionalities that it provides? (Note: In this paper, we will stick to the definition of [Leuf, Cunningham 2001], where *Wiki* stands for the concept as a whole and ***wiki*** stands for a particular implementation of the concept, based on the Wiki software available.)
Wiki is based on the following core characteristics, which make it so simple but yet powerful:

- users can browse and edit all the Wiki pages in a wiki with a simple web browser
- when writing content for a page, users can use "WikiWords" - words containing two or more capital letters - for two purposes:
  - When the WikiWord has **not** been used before in the wiki, a new Wiki page with the WikiWord as its name is created
  - When the WikiWord has already been used before in the wiki, a hyperlink to the Wiki page with the WikiWord as its name is created

With these simple characteristics, starting from a single "FirstPage", large communities of users have created, browsed, searched and maintained wikis containing thousands of cross-linked HTML-pages (see an example at www.zwiki.org).
There are various implementations of the Wiki concept. Most of them are open source. Their functionalities vary, the most important ones are:

- **Hierarchically Structured Pages:** Wiki pages are structured hierarchically. By default, a new page has the page from which it was created (by typing a WikiWord) as a parent.

- **Backlinks:** All Wiki pages pointing to a specific Wiki page can be identified. This makes the well-known unidirectional hyperlink bidirectional and thus makes it much more valuable.
- **Full-text search:** In addition to the ways of navigation that Wiki provides, there is the possibility to search the Wiki pages with a full-text search functionality.

The layout of pages in a wiki is customizable. In our context, we consider the one in figure 3 as useful.

### 4.3 Wiki's Advantages

Interpreting the Wiki functionalities these main advantages of Wiki as a platform for knowledge management in SMEs arise:

- It is easy to learn and it is fast
- It is a web-based, platform independent application, needing not much more than a TCP/IP connection and a web browser on the client
- on the server-side, it is also very lightweight and runs on various operating systems
- since most Wiki systems are open source, customizing a wiki is not a big deal
- all this keeps the costs rather minimal compared to other knowledge management solutions
- the hyperlinks in a Wiki represent relationships between information - an important element of knowledge [Mills et al. 2001]. The ability to follow them in two directions instead of only one (thanks to the backlink functionality) multiplicates the value of the knowledge.

## 5. Integration of Wiki and the K- & V-Matrix

Wiki has been chosen as a solution for managing "explanatory configuration knowledge", "unstructured configuration knowledge" and "Experiences". The main requirements for this solution were - among others - integrability with the knowledge ressources described in the K- & V-Matrix as well as other knowledge ressources. This integrability will be discussed on a conceptual as well as on a systems level.

### 5.1 Integration on a Conceptual Level

In figure 4 the integration on a conceptual level is indicated: The wiki offers answers to questions arising when working with the content of the K- & V-Matrix. Questions arising could be e.g.:

- "What does this customer property exactly mean?"
- "Why are these two technical properties not compatible?"
- "Why does this customer property require certain technical properties?"

The answers to these "Whats" and "Whys" are mostly contained in the "explanatory configuration knowledge". However, the frontiers between "explanatory configuration knowledge", "unstructured configuration knowledge" and "experiences" are rather diffuse, so we just say that "the answer is in the wiki". The integration between the K- & V-Matrix and the knowledge ressources in the Wiki is mainly based on a unidirectional relationship between elements of the K- & V-Matrix and pages in the wiki. Although it would also be possible to establish bidirectional relationships, this doesn't seem very useful, because users will rather go from the structured knowledge in the K- & V-Matrix into the details in the wiki and not the other way round.

### 5.2 Integration on a Systems Level

On a systems level, the unidirectional relationship from elements of the K- & V-Matrix to Wiki pages can best be represented with hyperlinks as a wide-spread and reliable concept for linking content. The K- & V-Matrix system and Wiki are both web-based, so the technical realization is not a problem. In addition to static hyperlinks to wiki pages, "search-hyperlinks" can also be defined, e.g. searching for a technical property across all wiki pages.
In the user-interface of the K- & V-Matrix system, the so-called "i-Button" is an important integrator: Being a simple "Information"-symbol, it is obvious that it is the element that guides the user to additional information related to the element next to the i-Button. Figure 5 indicates the system architecture and the integration on a systems level.

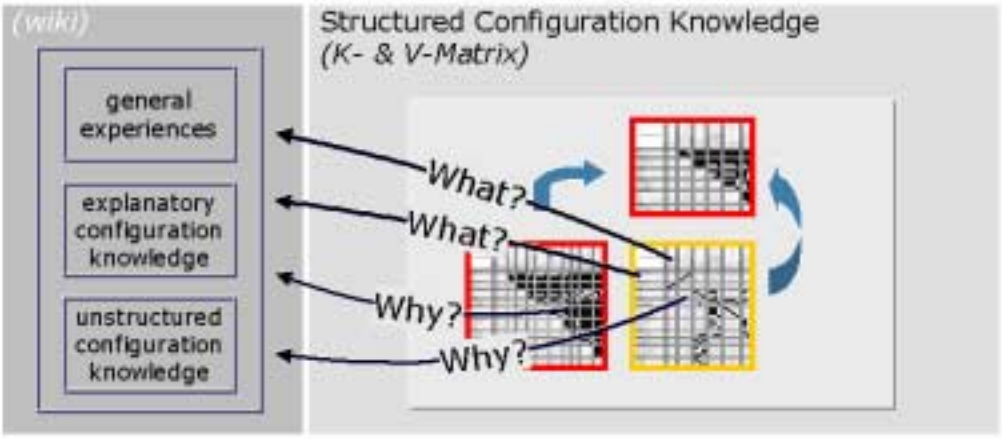


**Figure 4. Integration of K- & V-Matrix and Wiki on a conceptual level**

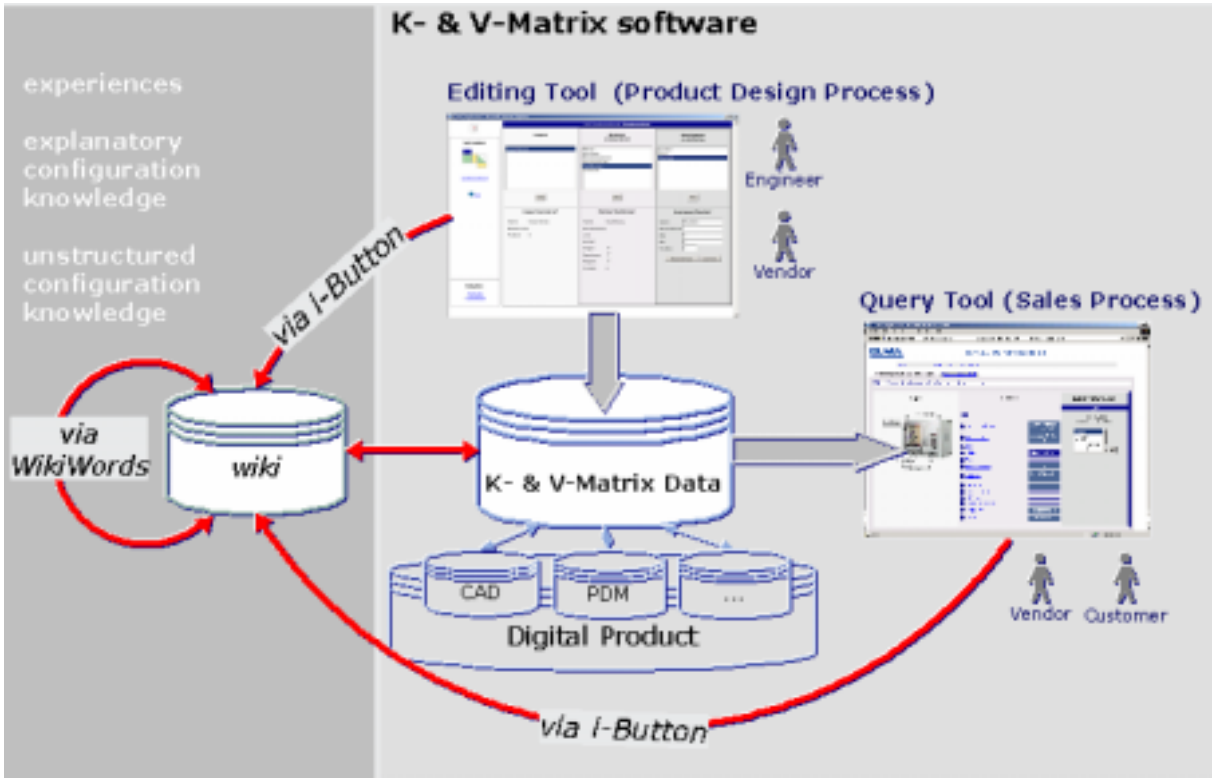


**Figure 5. Integration K- & V-Matrix and Wiki on a systems level**

### 5.3 Mutual Benefits of the Integration

Summarizing the benefits gained by integrating the K- & V-Matrix and Wiki we can state that:

- the wiki "extends" the knowledge that can be described with the K- & V-Matrix. Since it uses plain text as the description language, it is easy to use but still unlimited in the complexity of the knowledge described.
- the K- & V-Matrix serves like a "content map" for the wiki, providing an overview of its content and bringing structure to it. It facilitates the navigation in the numerous Wiki pages, and allows to navigate directly to the information of interest. The larger the content of a wiki, the more important becomes this "overview".

## 6. The Knowledge Acquisition Cycle Associated with this Approach

[Nonaka, Takeuchi 1995] have presented the *Four Modes of Knowledge Conversion* of the *Spiral of Knowledge Creation*. These are *Externalization*, *Combination*, *Internalization* and *Socialization*. In this section this approach is brought into the context of the K- & V-Matrix and Wiki (see figure 6).
The knowledge aquisition process in Wiki itself is based on three simple steps:

- the implicit knowledge is externalized by simply describing it in plain text (and eventually graphics) on a Wiki page
- the knowledge - the Wiki pages - is organized hierarchically
- the knowledge is linked with other knowledge - this can be links to other Wiki pages or to any other kind of knowledge ressource.

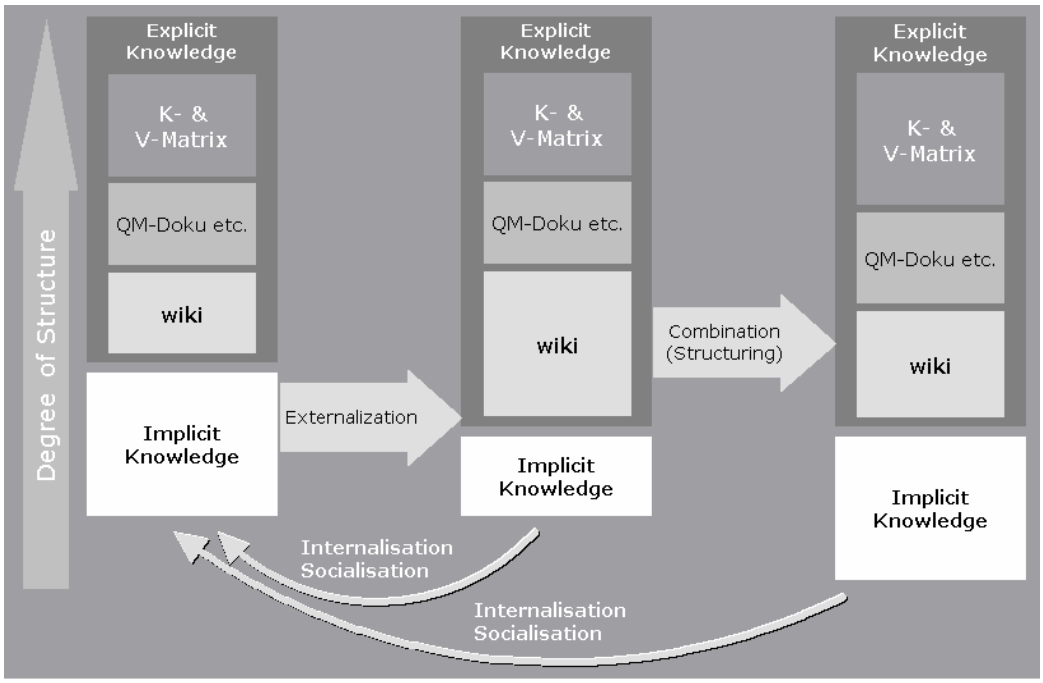


**Figure 6. Knowledge acquisition process with Wiki and the K- & V-Matrix**

With increasing number of Wiki pages and user experience, these three steps will take place simultaneously. Figure 6 summarizes these three steps as *Externalization* and shows the increased content of the wiki after it. Figure 6 indicates further, that the following process of *Combination* reduces the content of the wiki and increases the content of the K- & V-Matrix and other knowledge ressources (e.g. QM-documentation). In our context, *Combination* includes:

- linking from elements of the K- & V-Matrix to Wiki pages and
- reflecting and restructuring Wiki-content and moving parts of it to the K- & V-Matrix and other knowledge ressources.

During these steps more experiences are made and new insights gained, which results in more implicit knowledge as indicated in figure 6. The following processes of *Internalization* and *Socialization* are also part of the *Spiral of Knowledge Creation* and create more implicit knowledge, so that the procedure described here should start again from the beginning. This is what we call the *knowledge aquisition cycle* associated with the K- & V-Matrix and Wiki.

### 6.1 Introduction of the K- & V-Matrix and Wiki in a Company

Obviously, before the knowledge aquisition cycle described above can come into action, some preparational steps have to be undertaken. First of all, the K- & V-Matrix and Wiki have to be introduced. We recommend that Wiki is introduced first, because it is a rather simple concept with

immediate benefits. An increasing Wiki content automatically generates the need for a more structured and visual knowledge description method and thus understanding and acceptance of the K- & V-Matrix will be better.
Guidelines of the preparational steps to be undertaken are available at www.k-v-matrix.info.

## 7. Conclusions

The combination of the K- & V-Matrix and Wiki has proven a simple but effective approach for knowledge management in product design. It has been applied in an SME designing and producing gear-boxes and within short time, a knowledge base has been created and is growing every day.
Wiki comes with a cultural change in the company and a new awareness towards knowledge. This came out quite clear in our case study: Whenever some new information occurs, now, the product designers just say "write it to the Wiki", being sure that the information will be "safe" there and available to everybody. This is obviously a much more effective way of managing information compared to how it was handled before, when everybody had his stack of papers or a notebook to store information which he considered important.
Although the results are good and benefits have been gained right from the start, further investigation is necessary especially concerning the structure of the Wiki pages as well as the page names. Guidelines are necessary to enable SMEs to create knowledge bases without intensive external support. The provision of templates has proven to be effective in the past and will be investigated.
Also, the integration of other - existing - knowledge ressources such as e.g. Quality Management documentation must be investigated on a conceptual as well as on a systems level. This could even give Quality Management a new importance and increase its acceptance among product designers.

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