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Cultivating Knowledge methodically: Improving analysis resolution with DeCoDe and FMEA

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BEING AHEAD

Being ahead means knowing the art of cultivating knowledge and making profit of what is already there. In terms of using methods this means, that it can’t be a researchers aim to reinvent the wheel, but it definitely must be the aim to widen the scope so that openness leads to an efficient use of established methods or approaches. Quality management methods like FMEA, FTA or others have been successfully used in development approaches of the last years and consequently, engineers are familiar with those methods. The problem is that they are in most cases used as stand-alone-solutions and the gained information is only merged in the experiences of the teams, or in case of different users, only put together in the documentation.

In terms of information being ahead means consistently using the information that is already produced. Hence, results are not just put together but merged, re-used, enhanced and cultivated to a continuously growing data pool.

As developing a product (including also non-hardware systems or services) is not a linear process - there are steps back, loops, simultaneous parts, concurrent ways or other events which makes it unpredictable – being ahead means also having the data prepared and accessible when necessary.

PROJECT SCOPE

The main focus of the research project is the development of a methodical platform which is on the one hand a method for systems analysis and which works on the other hand as database and data source for further detailed analysis. It orients towards preventive development methodology through supporting a consistent knowledge management.

Very much emphasis is put on flexibility, so that customisable PLCs or company-specific strategies are in scope as well as the independency to organisational conditions like e.g. team-structure. The method aims to cope with changing circumstances, changing requirements and the possibility of simultaneous engineering of different solutions/versions/modules.

DeCoDe (Demand Compliant Development) is the outcome of the project. In the last years we strove to improve DeCoDe bearing in mind that it aims to be a living method in development projects. In 2005, we showed at the QMOD DeCoDes ability to assist in early phases. Now, this paper shows with the example of the combination of FMEA and DeCoDe how this method contributes to being ahead.

CONCEPT OF DECODE

The core concept of DeCoDe is modelling the analysed system through combining different views in a set of matrices. In a top-down approach, the systems product components, functions and processes are described as hierarchical structures. With those tree-like structures, matrices can be set up which relate their elements to others. Fig. 1 shows with matrices 2, 3 and 4 such a set of combination.

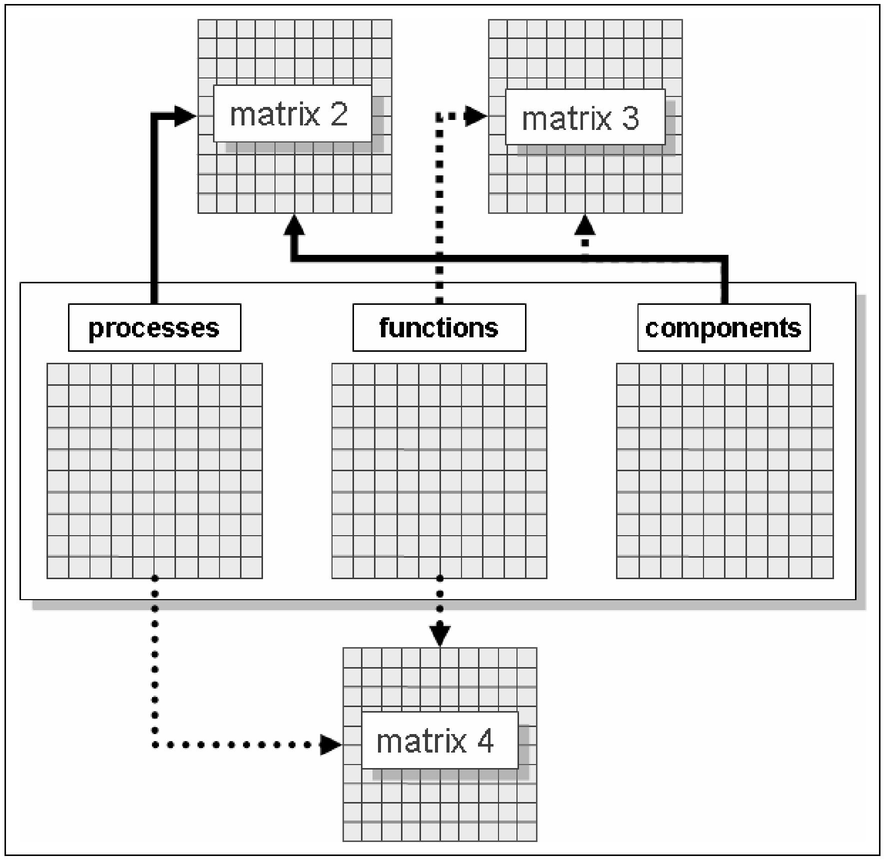

Figure 1. Combination to matrices [Ott (2005)]

The framework for the promised ‘demand compliance’ can be achieved by relating the structures to the requirements (cf. fig. 2 and fig. 1, matrix in the centre). Finally the set of matrices can be completed by relating each hierarchical view with itself.

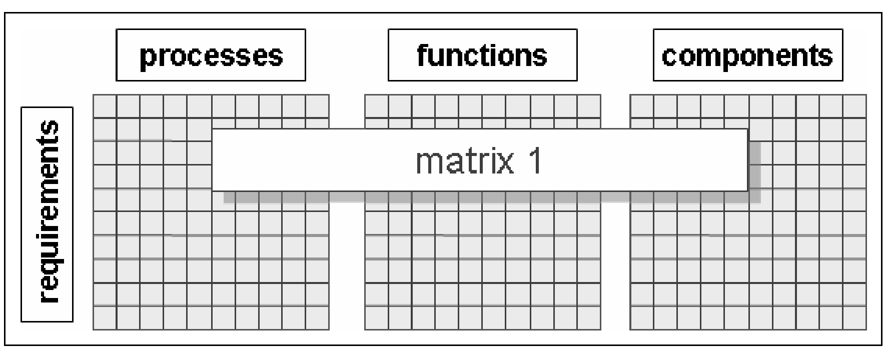

Figure 2. Relating structures to requirements [Ott (2005)]

With a full set, a 100% model of the system can be established. Though the extent of this full set enormously grows with the complexity of the system, the advantage still dominates that the matrix cells completely represent all possible relations. Depending on the development status and the aims of the current phase, the necessary set can be strategically compiled and by this adopted to the specific conditions. Not only the combination of matrices means this flexibility, but also the decision how detailed the hierarchical structures are set up. An iterative detailing of structures, matrices and content of the cells supports the usability in every phase of the development process.

In the cells of the matrices ratings, cognitions and actually results of external investigations to interrelating pairs of elements can be documented. The basic information for each pair of element is whether a relation exists or not. As example for the binary type, the components-functions-matrix gives the possibility to compare both structures and check if every planned function has assigned components which contributes to the realisation.

An advanced version could be characterised by numerical descriptions. This makes it possible to express the type (supporting/positive or impeding/negative) and intensity of the relation. Numerical ratings imply the possibility to calculate interim results which can give a notion of the elements contribution to the systems performance or express the comparison of competing modules.

Provided that elements are unique or at least clearly identifiable within its structure, a well-defined bidirectional link to external investigations can be established and the exchange of information can be reproduced.

FMEA

The FMEA (Failure mode and effects analysis) is an inductive method where possible failures of the system are identified, their causes and finally their effects on the system are pointed out. Its intended purpose is mainly to identify problems that interfere with functionality or safety and to enable improvements of the system by creating knowledge (DIN, 2006). It has achieved its good reputation especially in the automotive business, because it realises highly detailed and reliable results using a simple approach.

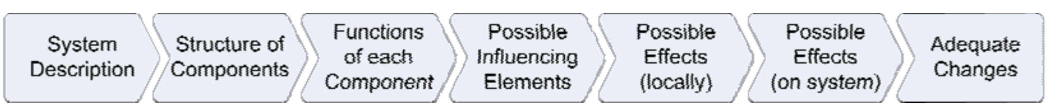

Figure 3: Chart of basic steps

At the very beginning of each FMEA an analysis of the system is required. Therefore it is broken down into its elements on a certain level. Each identified element is well analysed and described regarding its functional meaning to the system and the relations with other elements. The EN 60812 suggests building a block diagram which shows the links and the type of relation (e.g. flow of information). On the basis of this pre-work, every element is examined to find potential conditions (failures) where the element loses its ability to fulfil the given function(s). For the following steps the links of the elements are considered. First, to each failure possible causes are collected and in the second step all effects are listed, that have local negative impact and / or that possibly lead to impact the function(s) of the overall system.

The examination is usually done with the help of a given form. This form has a column for every step of the explained procedure. Every element, failures, failure causes etc. are listed one below the other to realise the aimed completeness of the

FMEA. It is a bit problematic for the user to keep the interim results in mind, because every link between the elements is at least assessed twice as always causes and effects are taken into consideration. Furthermore, for each failure the possibilities of recognition and suggestions for prevention are defined.

The aimed output of a FMEA is the detailed analysis itself (e.g. systems structure or interdependencies between elements), because it means a great knowledge about the system, and a list of suggested modifications.

FMEA can be extended to a quantitative assessment of the risks of identified failures. The FMECA (Failure Modes, Effects and Criticality Analysis) calculates numeric numbers standing for overall criticality and the resulting priority.

SYNERGETIC COMBINATION

It is quite common in development projects to establish a tool-box of standard methods which are utilised for specific tasks and by this combined in the overall project documentation. Quite a number of research approaches deal with the synergetic combination of methods, but hardly any deal with how to combine the concrete data. As example, for the FMEA the EN 60812 suggests to combine the inductive approach of the FMEA with the deductive approach of the FTA (Fault tree analysis) in order to complement one another and to improve reliability.

The descriptions of the two methods DeCoDe and FMEA show many similarities regarding the produced information. Most conspicuous is that for both methods the system has to be broken into its elements so that in both cases a hierarchical structure has to be produced.

Additionally, there is a lot more:

- For the FMEA the functions of each element have to be described.

  → DeCoDes components-functions-matrix (matrix 3; cf. fig 1) aims to show those relations and their characteristic.

- In order to identify causes and effects, the FMEA looks at the interrelations between the elements, creates a detailed list and explains their characteristics.

  → DeCoDes components-components-matrix does the same.

- The FMECA calculates numerical results representing the criticality of a failure out of meaning for the system, probability of recognition and probability of occurrence. This is indirectly also a rating for the relation between the concerned elements.

  → If the relations are rated numerically, DeCoDes matrices do the same.

Those similarities offer a great chance to combine the data of the methods:

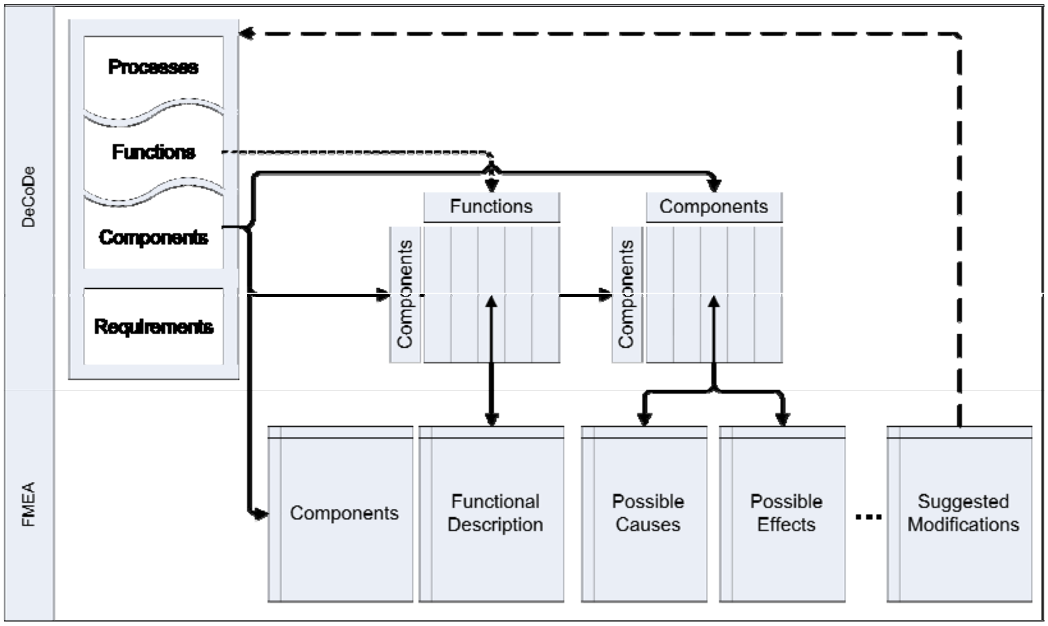

Figure 4: Data flow chart for method combination

The chart shown in fig. 5 shows that the two methods can be effectively combined by taking data from the one to the other, further analysing it and passing the result with enhanced reliability back. The different viewpoints support completeness and an improved resolution of the overall concept. Beyond this, the advantage lies not only in the value of the content but also in the efficiency of the application of the methods: Work needs not to be done twice so time and resources can be concentrated on important steps.

DeCoDes flexibility is realised for the combination with FMEA by filtering the structures to hierarchical layers or according to their rating in advance without loosing sight of excluded ones. Many ‘small’ FMEAs can be performed and continuously improving DeCoDes data.

The FMEA is here explained only for failures defined as ‘not fulfilment of components functions’ as it is done by the standard. The method can also be performed concentrating on processes instead of components (Process-FMEA) or with ‘not fulfilment of requirements by functions’ as definition of failures. Consequently, the methods’ combination can be extended to the other structures of the system, more data included and more interrelation further analysed. The resulting synergies can be yet increased.

CONCLUSION

For the combination of DeCoDe and FMEA it has been shown that a beneficial combination is possible. Hence, DeCoDe’s functionality as knowledge database for conceptual method combinations is substantiated and thus valuably contributes to being ahead.

Such combination of methods offers an efficient possibility to systematically cultivate knowledge about a system. Similar synergies can be shown for other methods like FTA, computer based simulations, DoE or classic test series.

We are currently setting up a software-tool which realises DeCoDes set of matrices as database. This serves the independency to certain types of data presentation and facilitates the sharing of data. A method dependant user-interface is implemented to easily access the data and work with it. Methods like FMEA and FTA access the same data as DeCoDe does and by this an indirect combination of methods is made possible.

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