INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED15
27-30 JULY 2015, POLITECNICO DI MILANO, ITALY

INTEGRATED VALUE ENGINEERING - FRAMEWORK FOR THE APPLICATION OF METHODS FOR VISUALIZATION OF INFORMATION

Sadi, Tarek; Behncke, Florian G. H.; Maisenbacher, Sebastian; Kremer, Simon
Technische Universität München, Germany

Abstract

Technical products are becoming more demanding in terms of their requirements for functionality to the customer and price. Approaches of cost management companies in increasing the customer value of their products. A relatively new approach in cost management is the approach of integrated value engineering (ive). It combines structure-based matrix methods with approaches from cost management to systematically identify potentials for cost optimization. A benefit is that all steps of the approach are displayed in one model and correlations between cost potentials on several product domains are traceable.
However a major challenge in the application of new methods results from their increasing specification on certain topics, what easily results in difficulties concerning the flow of information. Information sharing is based on specific forms of representation, which cannot readily be interpreted by all stakeholders involved in the product development project. Therefore, this paper presents a framework for an early-phase stakeholder analysis that extracts relevant information to fit individual stakeholder interests concerning the underlying level of detail and result-orientation.

Keywords: Design costing, New product development, Integrated product development

Contact:
Florian G. H. Behncke
Technische Universität München
Institute of Product Development
Germany
behncke@pe.mw.tum.de

Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

1 INTRODUCTION

Technical products become more demanding in terms of their requirements for functionality and price. At the same time, product development methods and frameworks are get increasingly specific that easily results in difficulties concerning the flow of information. Information sharing is based on specific forms of representation, which cannot readily be interpreted by all people involved in the product development project. Addressing these issues, this paper presents a framework for an early-phase stakeholder analysis that extracts relevant information to fit individual stakeholder interests concerning the underlying level of detail and result-orientation. This framework is developed to supplement the IVE approach by (Behncke et al. 2014) using various methods of visualization to transport information. Therefore, this paper provides an introduction to cost management, integrated value engineering (section 2) and visualization methods (section 3) as basis to the concept for the analysis of stakeholders (section 5).

2 COST MANAGEMENT AND INTEGRATED VALUE ENGINEERING

To compete in a global market, companies to offer products with attractive price-performance ratio. The methodological approaches "Target Costing" (TC) (Ewert & Ernst 1999) and "Value Engineering" (VE) (Haskins 2010) follow this objective. TC aims to determine target costs for product development, so that the product is developed economically, thus refers to resource efficiency. VE aims to increase the functionality within the target cost (Cooper & Slagmulder 1997).
"Integrated Value Engineering" (IVE) combines these two approaches to an integrated approach (Maisenbacher et al. 2013). The product is modeled by its requirements, functions and components using a multiple-domain matrix (MDM) (Figure 1). Components are hereby assigned to functions and functions to requirements. These correlations are used to calculate target costs from requirements to target costs of components and current costs from components to current costs of requirements. Finally the IVE process compares target-costs and current costs for all three domains to identify potentials for optimization (Behncke et al. 2014).

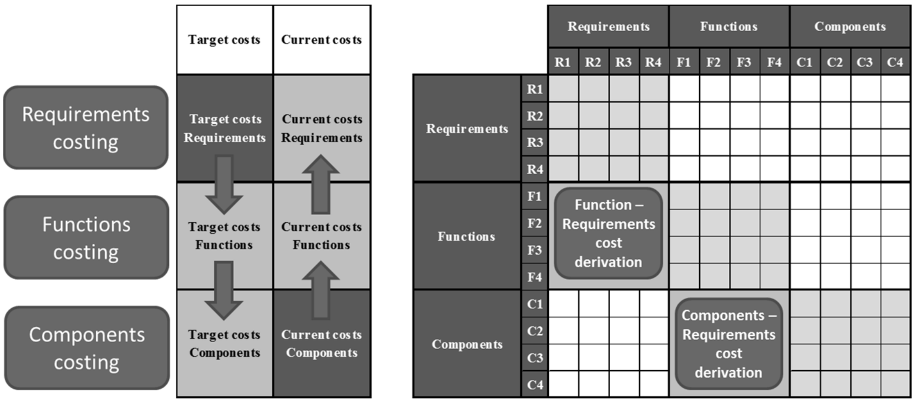

Figure 1. IVE basic model (Maisenbacher et al. 2015)

The IVE process assigned to this model consists of five steps, each of which includes a variety of activities. In a preliminary step (IVE-0), the scope of the initiatives is set which includes the identification of stakeholders. Based on this information, the next step (IVE-A) describes the acquisition of information. IVE-B then focuses of information analysis to identify potential improvements by comparing current and target costs. IVE C contains the implementation and monitoring of the derived potentials. A last step (IVE D) is dedicated to the controlling and evaluation of the initiatives carried out from IVE-A to IVE-C (Figure 2).

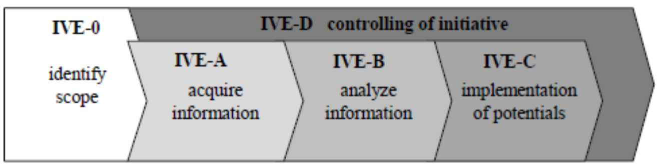

Figure 2. Procedure for the IVE initiatives (Behncke et al. 2014)

3 VISUALIZATION METHODS

With the definition of knowledge visualization Burkhard (2005) links visualization to knowledge management. “Knowledge visualization examines the use of visual representations to improve the transfer and creation of knowledge between at least two persons” (Burkhard 2005). In this case, the focus is mainly on the methodology of the visual representation of data and correlations using diagrams. In this context it is discussed how visual representation forms are able to represent information regarding structures and values. Figure 3 illustrates the purpose of the visualization methodology, the translation of abstract structures and values into visualization methods that further communicate the underlying information to a target person.

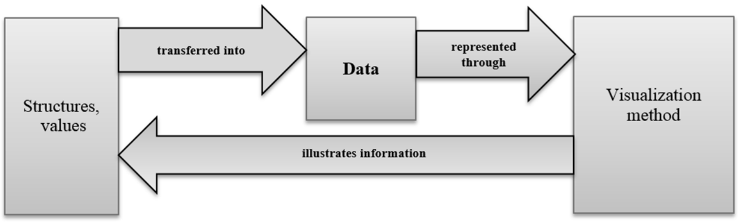

Figure 3. Purpose of visualization

Values and conceptual structures are translated into visual forms using their characteristic data, which then illustrates the relevant information. Therefore, the purpose of visualization is not only to represent data in diagrams, but to enable the viewer to understand the underlying structure behind the data (Chen et al. 2008, p.6).

The most important requirement for a visual representation is the comprehensibility of the illustrated values or structures. Graphical representations should further encourage the viewer to critically think about the illustrated data, exploit the available space, provide different levels of abstraction and support the application, e.g. tabulate, describe and explore data. It should be avoided that graphical representations distort the content shown or distract the viewer from the content (Tufte 2001).

To assign visualization methods to specific applications, it requires criteria, which show the advantages and disadvantages of a visualization method. Based on Zelazny (2001) criteria for the selection of a visualization method are the inclusion or representation of large amounts of data, time series, structures, discrete values, relations and contexts, financial aspects, rankings, combined statements, trend developments and frequency distributions (Zelazny 2001, p.27).

After this brief introduction to visualization in general, the following section provides a closer view on visualization methods. Simple and obvious forms of visual representation are for example logos, cartoons, portraits or photos, as well as diagrams, process diagrams or matrices. In order to organize and structure the large amount of potential forms of visual representations a definition of "graph" is given to distinguish it from the term "picture”. A graph refers to a structured visual form that is used to convey the circumstance of a situation using abstraction in order to clarify a particular statement. In contrast, a "picture" provides a visual representation of reality as clearly as possible. Examples are photos or portraits. Figure 4 shows the definition of graphs to pictures and further the classification of graphs into value representations, structural representations and representations for multidimensional values, as well as their subdivisions (Meyer 1996, p.40).

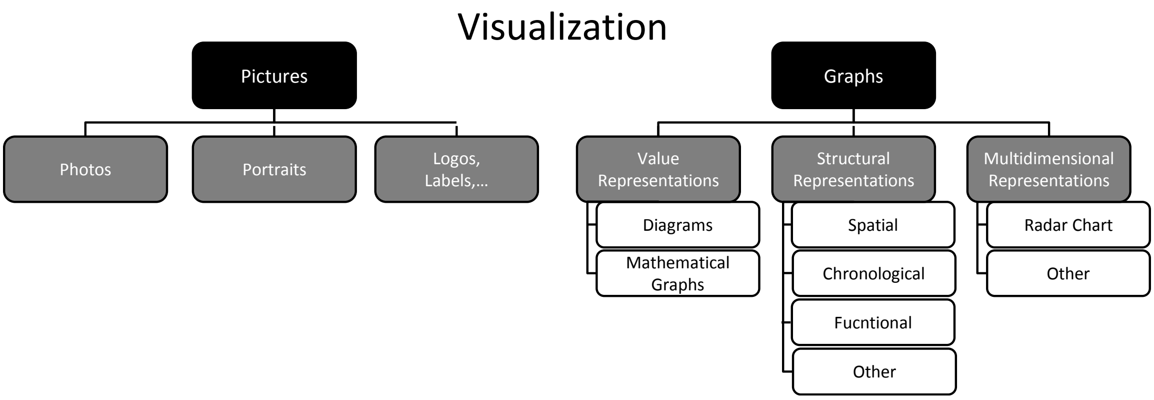

Figure 4. Classification of visualization methods (Meyer 1996)

Value representations

Value representations show values and their interrelationships in a suitable graphic form, e.g. in charts or mathematical graphs (as functions through points or curves). Further, diagrams can be divided into bar, column, curve, points, structural and composite diagrams, and other chart types. With bar diagrams values are converted into horizontal bars which enables comparison. Especially rankings can be conducted well with this form of visual presentation. A very popular application of a bar diagram is the "Gantt-Chart" used in project management. This visualization method can be very helpful if values are linked to points in time. With horizontal bars, a timeline can easily be attached.

In column charts values are converted into vertical bars. Applications for this form of visual presentation preferred for direct value frequency comparisons. Frequency distributions indicate how many times an object (frequency) appears in a series of successive size classes (distribution) (Zelazny 1999, p.41). In Figure 5 (left) a product test with different products on the basis of a certain criterion is shown as an example for a column diagram.

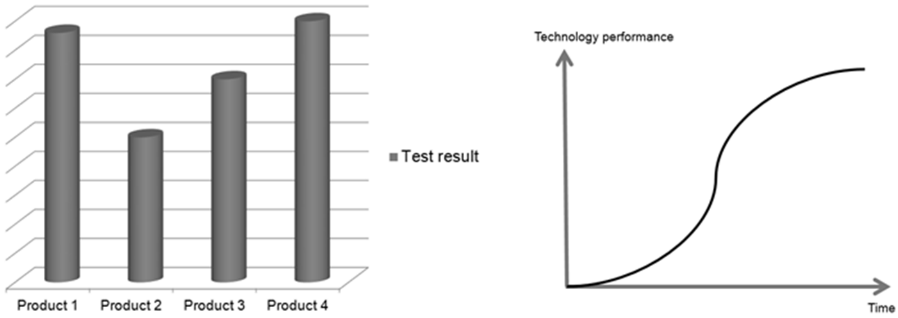

Figure 5. Product test results in form of a column diagram (left) and S-curve presentation of a product life cycle as an example of a curve diagram (right)

In curve diagrams, values are presented in form of curves. Curve diagrams are preferable when a large number of values needs to be displayed (Meyer 1996). An example for this diagram is the S-curve presentation of a product life cycle (Figure 5 right). Curves are also suitable to represent mathematical functions. In this case, it is called mathematical graph of a function. Further, statistically generated points can be connected with each other to form a curve that then can be approximated with a mathematical function to be extrapolated to show and identify trends.

Another way of presenting values is to show them in points. These values representation is useful for random distributions and for mappings of variations (see Figure 6 left). Point diagrams are mainly used to cluster random distributions (Meyer 1996). In Figure 6 (left) the viscosity variation of a substance is shown over time. Especially for a reasonable number of empirically collected data points is useful.

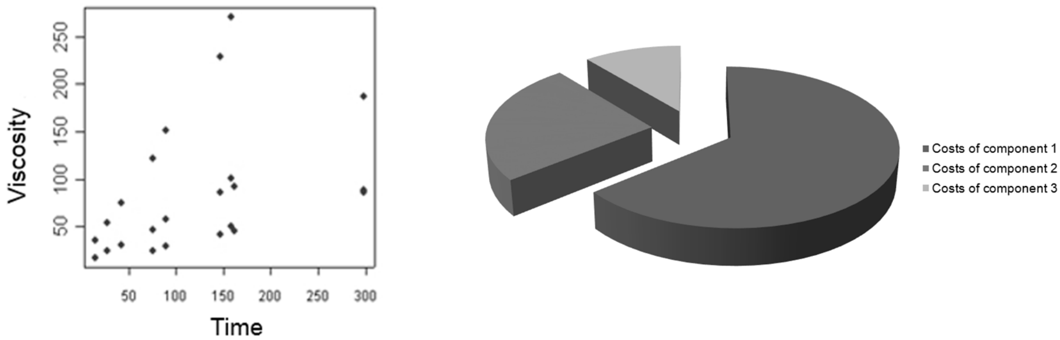

Figure 6. Representation of scattering as an example of a point diagram (left) and Pie Chart as an example of a structural diagram (right)

Structural diagrams, mostly used in form of a pie chart, are composed of a (geometrical) structure that shows values as partial areas of a whole structure (Meyer 1996 p. 44). A structure chart is appropriate if "parts of a whole" should be displayed (Zelazny 1999). In Figure 6 (right) the costs of individual

component costs are displayed in relation to the total product costs to demonstrate the use of a structural diagram (in form of a pie chart).
Composite charts can display different chart types combined. This form of presentation is applied when multiple statements or relationships should be illustrated in one diagram. In Figure 7, such a case is exemplified. This combination chart both the sales performance and the number of employees is illustrated, for example, to draw conclusions about a possible link between the two different factors.

Figure 7. Example of a composite chart: combination of column and curve diagram

Structural representations

In contrast to value representations, structural representations are visualize relationships between objects, and not between values (Meyer 1996). Structural representations can be distinguished in spatial, temporal and functional structure diagrams and other special cases as to be seen in Figure 3 (Meyer 1996). Spatial or topological structure representations illustrate spatial relations or allocations of objects. Temporal structure representations illustrate temporal relations and processes. This form of representation is applied in the mapping of processes or in the visualization of plans (e.g. project management, strategic planning). Figure 8 (left) shows a product development process over four months as an example of a temporal structure representation. The conceptual, detail and implementation phases is displayed with blue arrows pointing in the direction of the time axis. Processes and milestones can be well presented with this visualization method.
In functional structural representations conceptual and functional relationships are visualized (Meyer 1996). It is applied in the representation of hierarchical-, organizational and functional modellings (hierarchical, relation-oriented, user-oriented and conversion-oriented) (Lindemann 2009). Figure 8 (right) shows a hierarchical functional model as an example of a functional structure representation.

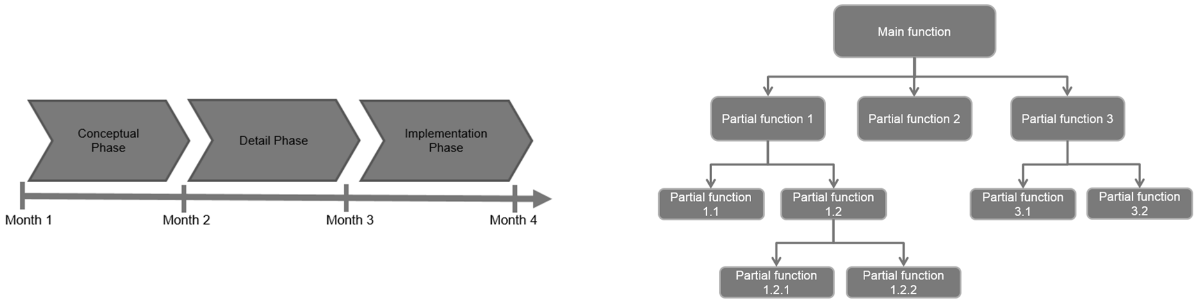

Figure 8. Product development process as an example of a temporal structure representation (left) and hierarchical functional structure model showing the functionality of a product as an example of a functional structural representation (right)

A special case of structural representations is the Venn diagram. The aim of this form of presentation is to illustrate relations of different quantities (affiliation, intersections, definition). This visualization method is used to show uniform, overlapping or confining properties of a group in comparison with other groups.
In some cases it is necessary to display data based on multiple value dimensions. The aim of such kinds of visualization methods is therefore the visual presentation of multidimensional data (Meyer 1996). For example, a radar chart can be used to display a set of data on several axis. Radar charts are particularly concerning the comparison of several characteristics with several features.

Special cases

A special visualization method is a matrix or a graph. Both can be transferred into each other and are used for tabular comparison, for example, for the comparison of products and their properties Therefore, this visualization method is listed as a special case. As this paper concerns the "Integrated Value Engineering" (IVE) approach, the visualization of information via a MDM (Behncke et al. 2014) (Maisenbacher et al. 2013) as an example of a matrix representation is considered relevant.

4 OBJECTIVE AND RESEARCH METHODOLOGY

In practice, it turned out that the complexity associated with the IVE procedure is not always easy to overlook. In particular, the clear presentation of results, which are often derived from large matrices (MDM's) for decision-makers is difficult. The efficiency of the information flow is crucial for the quality of the product as well as for in-time delivery. The IVE methodology uses forms of visualization, e.g. large matrices to visualize the dependencies of a product. The size and the information content of these matrices increase with the complexity of the product. Therefore, information with a certain degree of complexity cannot easily be communicated with project partners. The project team is dependent both on input from knowledge sources (e.g. from sales and marketing staff) as well as on the preparation and presentation of information for decision-makers. As a result it is challenging to clarify which information is required or passed by different stakeholders in IVE. The visualization and preparation of the information is a second demanding issue to guarantee a most efficient integration of stakeholders in the information flow.

Thus, this paper aims to make relevant information adaptable and understandable for all stakeholders of the project. In addition, the methodology is supported by visualization methods for intuitive comprehensibility of complex relationships. Furthermore, the development of a methodological approach is presented, which adapts information to fit individual stakeholder needs. Within this concept various forms of visualization methods play an important role.

5 CONCEPT FOR THE ANALYSIS OF STAKEHOLDERS

The primary goal of a stakeholder analysis is to identify the roles of the people involved or interested in a project and further to make the information flow as efficient as possible. The stakeholder analysis needs to provide information on how process step results should be prepared for various stakeholders. It should also clarify whether visualization methods, explicit data, or a combination of both are needed to enable the information flow to be as efficient as possible.

The concept proposed in this paper maps relevant stakeholders in a portfolio. The two dimensions are "extend of given *Input*" on the x-axis and "extend of interest in project *Output*". Stakeholder are evaluated on a scale from high (4) to low (1) in both dimensions and entered into the portfolio as dots with a reference to their actual hierarchy level in the company: A for top-management, B for middle management and C for operational employee. The three relevant quadrants show the characteristics "Decision-maker", "Team member" and "Knowledge holder" (Figure 9).

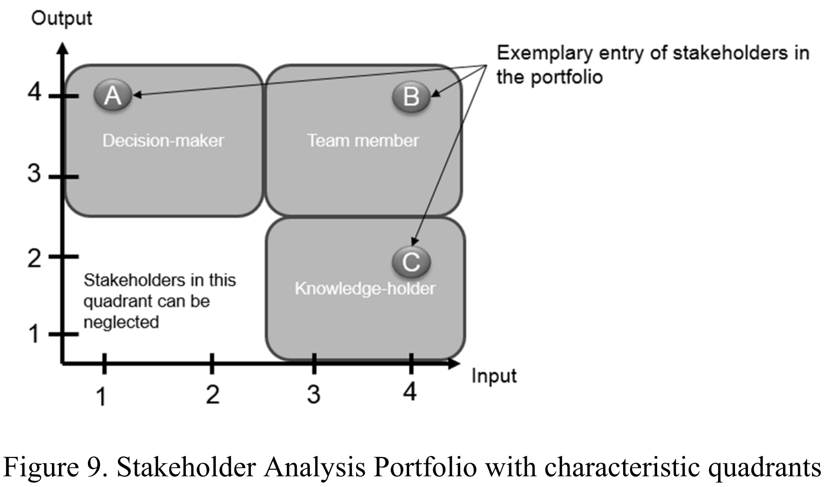

Figure 9. Stakeholder Analysis Portfolio with characteristic quadrants

Figure 10 further provides a summary of strategies on how to communicate information with different stakeholders. On the left axis, the extent of the (visual) processing of information is shown, the right axis shows, whether the focus is on information distribution or -acquisition regarding each stakeholder. The majority of decision-makers are supplied with result-oriented and visualized information to deliver intuitively understandable information. Regarding the flow of information they are mainly relevant for information distribution. Team members are located centrally on both axis, since both the acquisition and distribution of information is relevant as well as the extent of information visualization. Knowledge holders are located rather low on both axis as information acquisition plays a major role. They provide detailed information for the project team.
The following chapters provide an overview of different strategies by presenting specific methods of acquisition and distribution of information for individual stakeholders.

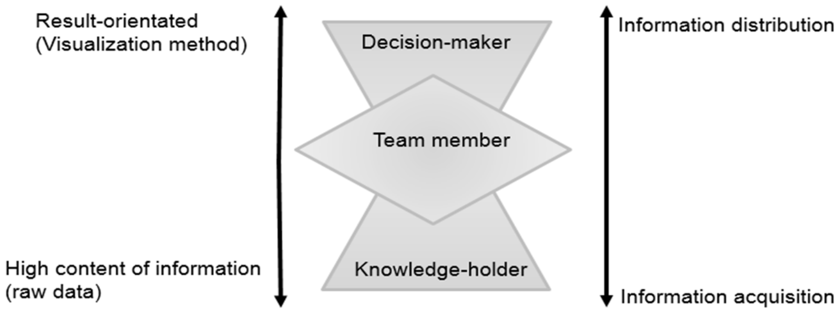

Figure 10. Strategies for information distribution and acquisition as a result of the stakeholder portfolio

Information acquisition within Integrated Value Engineering
Acquisition of boundary conditions and other information about the project schedule usually refers to the requirements and desires of the person who commissioned the project. This information is acquired through lists, e.g. a list of requirements (Pahl et al. 2007) or results-oriented goal formulations like a planned cost savings with the re-design of a product. Visualization methods play no significant role in the acquisition of information in IVE-0, as the input is mostly given in textual, explicit form. In IVE-A, relationships between system elements and between the required manufacturing processes can be identified by knowledge holders completing structural representations (especially spatial and functional structure representations). Information on target cost can be acquired in various ways, usually supported by raw data, but also by values representations (e.g., column or graph). The project team can obtain the required information, knowledge or expertise via questionnaires or tables and can visualize them by an appropriate representation of values if necessary. Information on the list of requirements are developed by team members in individual or team work can be acquired by surveys and interviews. In IVE-B, actual costs and potentials related to cost reductions and increases in value are mainly developed within the team. In this step, the team-internal information flow and the subsequent distribution of information to higher hierarchy levels play a major role. Results need to be prepared and well documented for further processing steps. To evaluate the alternatives and the morphology of partial solutions in IVE-C, expert reviews can be collected using incomplete spatial and functional structure representations to be completed by the development department or production. The same is applicable for the visualization of the changing cost structures. These information can be visualized by values representations, such as column carts or curve diagrams by staff members of Finance. Within IVE-D, visualization methods cannot be assigned to specific initiatives, because this step is very variable in its execution.

Information distribution within Integrated Value Engineering
The project schedule is visualized in the form of a Gantt-Cart. With this visualization method, deadlines and dates are presented in an intuitive form for all persons involved. This presentation is very well known and therefore easy to understand. There are specific software tools available for Gantt.Charts as this method is a standard in project. This form of visualization can be used to address operational staff as well as decision-makers. The horizontal alignments from left to right support a quick read of the bar diagram, as this scheme coincides with the general direction of reading.

Results from IVE-A, as already mentioned, are mostly communicated within the project team. For cost structures comparative values representations (especially bar and column diagrams) are used in combination with detailed lists and tables. Cost aspects and comparisons are expressed by explicit numerical values. They can be displayed using column diagrams. This form of visualization promotes a comparison of numerical values as differences in the column height are very easily noticeable. Structural representations like pie charts are applied if If partial and total costs need to be presented (as parts of a whole. For the illustration of contexts regarding product components and manufacturing processes, technical drawings or sketches (as spatial structure representations) and functional structure representations (hierarchical function models and relation-oriented function models) are used to visualize relations.

After analyzing the information in IVE-B, especially the presentation of the detected potentials are relevant to decision-makers. Therefore, it is important to consider the potential cost reductions and increases in value interdependent. Structural representations and value representations can be useful in this case in order to perform a function analysis (Haskins 2010) and a value stream analysis (Rother & Shook 2003). Team members are supplied via a MDM which combines information on product and cost structure. For decision makers this type of representation is less useful, due to the complexity of the matrix. In this case, it makes more sense to derive relevant information from the MDM and to visualize them using functional structure representations (functional models) and associated value representations (e.g. for calibrating target and actual costs).

IVE-C includes a review of alternatives, a morphology of partial solutions and subsequent selection of a solution concept. Particularly relevant for decision makers are the advantages and disadvantages of the alternatives. Both can be visualized by comparative values representations connected with assessment criteria. Bar and column diagrams can be used as value representations as they provide an intuitive value comparison by the length and width of the bars or columns. The quantitative assessment of the criteria needs to be comprehensible in this case. More detailed data can be shown on request to provide a validation of the visualized content.

The final solutions should be described in detail by functional and spatial structural representations. Changes, such as a change in the composition of the total cost structure of a product is best visualized by value representations (e.g. pie charts). For team members matrix representations such as the MDM or the morphological box (Ritchey 2011) are applied in IVE-C in order to transport the necessary information for further processing. For the same reasons as in the previous subchapter, visualization methods for information distribution are not relevant for IVE-D.

6 EVALUATION AND DISCUSSION

This section deals with the evaluation of the proposed approach. Therefore, a questionnaire was used that gives the participants three visualization methods to choose from, in order to visualize an exemplary matter of the IVE procedure. One of these methods is preferable to the others, based on the results of this paper. The preferable visualization method promotes intuitive comprehensibility of information as a result of the characteristic properties of the method. In total, 32 persons completed the questionnaires of which approximately 50% have an engineering background. 18% among the 32 people have practical experience in project management. The paper focuses on an intuitive comprehensibility of information that is not requiring any experience. The first question asks for the most useful method to visualize a project schedule providing team members with relevant information. Possible choices are a functional structural representation, a temporal structural representation and a bar diagram (Gantt chart). The question asks explicitly to visualize parallel task packages. The functional structure representation is capable of displaying parallel tasks, however, this form of representation cannot easily visualize them in combination. The advantages of this method is rather the decomposition of a tasks into its subtasks. By using the chronological structure representation, time lines of a process can be visualized without a problem, although it is not suitable for detailed operations planning. In contrast to the Gantt chart, it relies on no standard pattern. With an increasing number of tasks and legibility of the information, this representation method suffers its comprehensibility. The Gantt chart is proposed as the most suitable visualization method. The survey results of question revealed a clear majority (75%) for the bar diagram (Gantt chart). 16% chose the chronological structure representation and 9% the functional structure representation.

Question 2 deals with the visualization of a cost comparison (target costs and actual costs) to be presented to a decision-maker. For this purpose two value representations, a column and a structure diagram (pie chart) and a matrix are given as possible choices. The matrix representation confronts the viewer with explicit data compared through their position in a table. To get the difference of the two values the viewer has to subtract them by themselves. This makes this method unsuitable for the task. Applying the pie chart, the viewer would wonder, whether target and actual cost add up form a larger unit. This representation would distract from actual visualization task, the cost comparison. Question 2 alludes to a comparison of value differences through the heights of two columns, i.e. the column diagram is most suitable to fit the task of cost comparison. The majority (78%) of the participants recognized this and chose the column diagram. 13% chose the structure representation and 9% the matrix.

In question 3 a holistic product structure has to be visualized and presented to people directly involved in the project. This raises the question of the balance between a detailed and result-oriented visualization. A functional structure representation, a matrix (using the example of an MDM) and a spatial structure representation (using the example of a technical drawing) are presented as pre-formulated answers. Project team members prefer a clear presentation form with high information content. The hierarchical modeling function can visualize the functional structure but not the detailed assembly, therefore it is rather unsuitable. The situation is similar with the spatial structure representation. It is able to show components in the assembly, but cannot connect functions or requirements with them. Therefore, this question alludes to the MDM, as this form of representation can represent both the component structure and functional relationships and requirements. The survey results revealed no absolute favorite choice for the visualization of this use case. 44% chose the functional structure representation chosen because this is the most frequently used visualization method in practice across industries to visualize functional structures. 31% chose the MDM and 25% the spatial structure representation. It gets clear, that the MDM requires prior knowledge to recognize its advantages. Even in the displayed reduced form it is not recognized as a visualization with the highest information content for team members. The MDM must be understood upfront by all project team members. Other stakeholders can be provided with derived reduced information, e.g. the cost comparisons using column diagrams and product structures using functional structure representations.

Question 4 dealt with the classification of solution alternatives to be presented to decision-makers. This emphasizes the intuitive representation of rankings. Participants chose from are a bar diagram, a structure diagram (displayed as pie chart), and a curve diagram. For comparison of rankings it should be visible at first glance which alternative is preferable based on a certain criterion. A large majority (78%) chose for the bar diagram because it shows rankings via bar lengths. 13% chose the structure representation and 9% the curve diagram.

Finally, question 5 is dedicated to the representation of tendencies or trends for decision-makers. In this case, it is assessed which visualization method provides the most intuitive representation for a large amount of data to be presented to a result-oriented person. In this case, three values representations are to be chosen from; a curve diagram, a column diagram and a point graph. Decision-makers expect result-based representations. The point diagram does not meet this requirement, since every single point of the statistics would be presented. It is the same with the bar diagram in which these points would be visualized by columns. As a result, question 5 alludes to the curve diagram as curves can be extrapolated graphically or mathematically to visualize trends. This was recognizes by most of the participants (87%) The point diagram was excluded by all participants. 13% chose the column diagram, as it provides a larger visual input for the viewer as the point diagram.

Concluding, the questionnaire supports the assumptions made regarding the result-orientation and the level of detail of the visualization methods and the information flow. The participants identified the correct visualization method for a given application in four of five use cases. Uncertainty was only visible in question 3. This question was intended to examine the intuitive comprehensibility of the MDM by showing a simple illustration of its basic structure. It is argued that MDMs require explanation in order to communicate its benefits. Furthermore, there is no correlation to be found between the experience of the participants and their choices among the presented alternatives in the questions. This paper gives an advice to choose a visualization method for the data acquisition and distribution. It has no claim to present the ideal solution to a certain visualization problem as there are far more criteria to be considered than the presented criteria in the portfolio (Figure 9).

7 SUMMARY AND OUTLOOK

This paper present strategies for the information acquisition of knowledge holders, the distribution of information for decision-makers and the communication within a project team through a concept for integrated stakeholder analysis. This concept aims to identify relevant stakeholders during the early phases of the project to link their specific role in the information flow. A stakeholder analysis portfolio reveal the stakeholders; decision-makers, knowledge holders and team members. They are rated based on the extent to which they provide input for the project team and to what extent they are interested in the generated output. A decision-maker has great interest in output, but mostly provides little input. Information for this character are result-oriented and mainly presented through visualization. Here, the reduction to the essentials is crucial. Raw data sets are used only on request for validation. In contrast, the knowledge holder primarily provides input, but is less interested in the generated project output. In this case, visualization is only necessary if it is essential for understanding of the data.

This paper focuses on the effective use of visualization methods that have different levels of detail and abstraction. Thus, they generate a flow of information in which each stakeholder is supplied with exactly the information he or she needs to conduct additional operations. The integrated stakeholder analysis enables an early focus on efficient information acquisition and distribution. Especially in IVE projects, the MDM plays an important role concerning information processing and information flow. An experienced person can derive much information from a MDM, while untrained persons face problems in extracting information from this matrix.

Further work concerns the information content of the MDM and develop standardized forms of (visual) representation in order to make them easily understandable. Here, combinations of value and structure diagrams would be required, making it possible to represent dependencies of the MDM domains in connection with the resulting structure. The objective in this case is that the MDM can be applied as a central tool in IVE procedures, both within the project team and in communication with various stakeholders in a standardized way. Further work should concern the representation of product variants with a MDM. Therefore, software solutions might be developed to create a MDM software tool that is capable of keeping the perceived visual complexity as low as possible.

REFERENCES

Behncke, F.G.H., Maisenbacher, S. & Maurer, M., 2014. Extended Model for Integrated Value Engineering. In Procedia Computer Science. Elsevier Masson SAS, pp. 781–788.

Burkhard, R.A., 2005. Knowledge visualization: The use of complementary visual representations for the transfer of knowledge. A model, a frame- work, and four new approaches. Eidgenössische Technische Hochschule ETH Zurich.

Chen, C., Unwin, A. & Karl, W., 2008. Handbook of Data Visualization, Springer-Verlag Berlin Heidelberg.

Cooper, R. & Slagmulder, R., 1997. Target Costing and Value Engineering, Oregon: Productivity Press.

Ewert, R. & Ernst, C., 1999. Target costing, co-ordination and strategic cost management. European Accounting Review, 8(1), pp.23–49.

Haskins, C., 2010. Systems Engineering Handbook,

Lindemann, U., 2009. Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden 3rd ed., Berlin: Springer.

Meyer, J.-A., 1996. *Visualisierung im Management*, Deutscher Universitätsverlag

Maisenbacher, S., Behncke, F.G.H. & Lindemann, U., 2013. Model for Integrated Value Engineering. In Proceeding of the IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2013). Bangkok, Thailand: IEEE.

Maisenbacher, S., Stanglmeier, M. and Behncke, F.G.H. (2015), "Integrated Value Engineering – Adapted Approach to Assess different Concepts of a Jet Engine", 2015 IEEE International Systems Conference (SysCon 2015), Vancouver, Canada (accepted).

Meyer, J.-A., 1996. Visualisierung im Management, Deutscher Universitätsverlag.

Pahl, G. et al., 2007. Engineering Design 3rd ed., London: Springer.

Ritchey, T., 2011. Wicked Problems – Social Messes. In Wicked Problems – Social Messes. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 7–18.

Rother, M. & Shook, J., 2003. Learning to see value stream mapping to create value and eliminate muda, Lean Enterprise Institute.

Tufte, E.R., 2001. The Visual Display of Quantitative Information, Graphics Pr; 2nd edition.

Zelazny, G., 1999. Say it with Charts, Dr. Th. Gabler Verlag; Auflage: 5Aufl. 1998. 4., korr. Nachdruck 2003.

Zelazny, G., 2001. Say It With Charts: The Executives's Guide to Visual Communication: The Executive's Guide to Visual Communication: Amazon.de: Gene Zelazny: Fremdsprachige Bücher 4th ed., Mcgraw-Hill.