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Using Decision Classification Criteria for Knowledge Acquisition and Transfer in Multi-Perspective Decision Making Processes

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Abstract

A main challenge in engineering represents the enabling of an effective and throughout acquisition and transfer of information and knowledge within decision processes. Decision processes can be very complex due to the various influence factors that have to be considered simultaneously. They can involve various stakeholders with different perspectives and levels of knowledge. The aggregation of different perspectives is vital for making good decisions due to the valuable insights and knowledge that they provide. To be able to support the decision making process effectively by integrating multiple perspectives an appropriate decision classification and description is very important. In this paper a generic classification and description method for engineering decision situations processes within large interdisciplinary companies is presented. The developed method serves as a basis for knowledge acquisition and transfer between the multiple perspectives involved in the same decision situation or process. The method was evaluated within four different product development decision situations at the vehicle manufacturer BMW Group in Munich (Germany).

1. Introduction

Decision making within product development can be a highly demanding task. Various influencing factors and boundary conditions have to be considered and analyzed. Also, many different stakeholders can be involved within a specific decision situation. The stakeholders can play an active role and be the actual decision makers or a passive role as they serve as information and/or knowledge providers. The decision makers and knowledge providers can have one or more perspectives and generate different views regarding the same decision situation. Typical "hard" perspectives are technical and functional perspectives. These can be completed by "soft" perspectives like organizational, social, personal and individual perspectives [1]. Examples for typical BMW perspectives are: geometry, electrical, building set and an overall vehicle development perspective.
Challenges occur due to the difficult identification and aggregation of different perspectives as well as transfer of information and knowledge between stakeholders within the organization [2]. Following research questions are stated:

- *How can decision situations be used as a basis for knowledge transfer within companies?*
- *How can knowledge be transferred and exchanged between stakeholders in critical decision situations?*
- *How can multiple perspectives be integrated and aggregated to generate knowledge transfer and well-founded decisions?*

Decision makers often fail to consider potentially valuable knowledge in making decisions. Defining the knowledge flow as well as a better appreciation of the decision making process will enhance the system support for decision making [2]. By combining different perspectives long-time decisions can be made which have a wide impact and integrate the interests of different stakeholders [1].
A solution for dealing with product development decisions is the application of criteria for decision situation description. These types of criteria can be often found in literature and can be used as an effective method for decision situation classification. By using criteria the characteristics of a specific decision situation can be determined. Decision situations can be described similarly and can be processed easier and more effective. This characteristic results from the high degree of abstraction that decision criteria display. Decision criteria can also be used to evaluate the same decision situation from different perspectives. The comparison of perspectives and an easier knowledge transfer are possible by using decision criteria embedded within an application framework.
The framework chosen in this case represents a template for decision situation description and evaluation. By using the template the communication and transfer of information and knowledge between decision makers can be improved. Valuable insights and results can be collected from the analysis of different participating perspectives. As a result we obtain an informed decision making process which induces product and product architecture improvements. The developed method has to fulfill several objectives:

- Improved multiple perspective integration in decision situations
- Improved knowledge and information transfer between stakeholders
- Improved decision situation transparency
- Improved generation of innovative decisions in an interdisciplinary environment

2. State of research and motivation

2.1. Interdisciplinary and multi-perspective knowledge transfer

Within decision making processes various stakeholders who act within different disciplines and possess multiple perspectives can be involved. Courtney [1] highlights that to manage the existing connectedness and the problems in actual decision making situations organizations must bring in multiple perspectives or worldviews and employ a holistic, systems approach in their thinking and decision making processes. Hall & Davis [3] propose a similar approach but based on value systems. The term “value” is hereby defined as an internalized belief regarding appropriate behaviour and impacts how an individual interprets information. The authors also state that: “Shared interpretation requires a method by which individuals agree on a classification scheme for interpreting facts and variables in the decision context.” This also underlines the importance of having a common basis for sharing and transferring information and knowledge between participating individuals or stakeholders. “Good information and knowledge transfer improves decision making, enhances efficiency and provides a competitive edge to every organization” [4]. In an interdisciplinary and multi-perspective environment information and knowledge transfer can sometimes be very difficult to realize.
The challenges displayed are overcome by using knowledge management methods, tools and systems [5]. For knowledge identification, acquisition and representation ontologies and knowledge road maps can be used.
For knowledge planning and analysis knowledge intensity portfolios and knowledge asset road maps are very useful.

Finally for knowledge transfer and application the methods: storytelling, best practice sharing and lessons learned can be applied efficiently [5].

2.2. Decision classification and support

To enable a high decision making quality, decisions have to be structured and classified. Examples for typical decision structuring and classification methods and tools are: taxonomies, ontologies, decision trees and specific structuring criteria.
Krishnan & Ulrich [6] classify decisions by five product development process steps: concept development, supply chain design, product design, performance testing and validation and production, ramp-up and launch. Harrison [7] uses four defined models for decision structuring. Hereby a rational (classical), an organizational (neoclassical), a political (adaptive) and a process (managerial) model is considered. Scherpereel [8] proposes a multidimensional decision-order taxonomy where decisions are classified according to three orders. First-order decisions typically have static properties and are associated with high levels of certainty and simplicity; second-order decisions have probabilistic uncertainty, are often complicated, and follow definable dynamic processes and finally third-order decisions highlight genuine uncertainty, complexity and dynamics. Decision trees are used as classifier for determining an appropriate action for a given case [9].
For decision making support many different methods were developed. Gorry and Scott Morton [10] initiated in 1971 one of the first support systems. They provided a framework for information systems with a distinction made between unstructured, semi-structured and structured problems. They declared that decisions that were semi-structured or unstructured would be supported by information processing systems called Decision Support Systems (DSS). In their literature review of decision support technology Shim et al. [11] describe how DSS who once utilized more limited database, modelling, and user interface functionality enabled a far more powerful DSS functionality. They also specify the need for integrating multiple perspectives within future DSS.
The displayed methods represent only a few examples from the vast field of methods and tools for decision structuring and support existing within literature.

2.3. Knowledge management and decision making

For decision making the right knowledge has to be provided on time. By integrating multiple perspectives different knowledge and solutions are available. The decision situations to be handled are hereby often characterized by high complexity. To deal with highly complex decision situations and to enable a good knowledge transfer Courtney [1] proposes the development of a new approach for DSS by integrating different perspectives. The proposed perspectives are hereby: technical, organizational, personal, ethics and aesthetics. Nicolas [12] analyses the impact of knowledge management on the decision making process within several case studies realized in different organizations. He identifies three different types of knowledge management strategies (KMS): technological KMS where organizational knowledge is structured and documented, personalization KMS where knowledge is tied to the person that developed it and socialization KMS, a combination between the first two strategies where knowledge communities inhabit the same knowledge space and interact with each other through relationships.
Frishammar [13] analyses the type of information used in strategic decision making processes, the type of information needed by decision makers and the ways decision makers obtain the information.

The importance of knowledge management in decision making processes is highlighted again by Kaye [4]: “Thus, a decision may be made on the basis of hunch and intuition, but is legitimated by dressing it up with supporting facts and data.”

2.4. Motivation and research gap

The presented methods and tools help users manage knowledge within decision situations. There is although little research regarding the integration of multiple perspectives within decision making processes and the management of the involved knowledge transfer. The multiple-perspective knowledge transfer can be seen as a special form of interdisciplinary transfer where one discipline can involve many different perspectives and views. The motivation for this research results from the need for improvement of knowledge transfer and perspective aggregation processes within decision making. By integrating multiple perspectives and managing the transferred knowledge the quality of decisions can be improved. Different views on the same problem and decision situation can generate a high variety of different solutions to choose from. These aspects are addressed by the three research questions stated in the introduction of this paper.
Decision structuring criteria can be very helpful in this case. To enable a better handling decision criteria are embedded within a template which can be used by various stakeholders with multiple perspectives for decision description and classification. The template can be used as a tool for knowledge acquisition and transfer between perspectives. Furthermore the template operates as a translation tool between stakeholders and represents a common basis for knowledge exchange. Describing decisions by using a common standardized template makes decision situations more transparent. This leads to an increase of stakeholder understanding and communication.

3. Realisation and results

The design of the decision classification template using criteria follows seven main steps:

1. Situation analysis and identification of challenges
2. Identification of roles and perspectives
3. Collection of descriptive criteria for decision situations
4. Structuring, prioritization and filtering of decision criteria
5. Embedding of decision criteria in an application template
6. Criteria-template application within decision situations
7. Action guideline development by using multi-perspective knowledge transfer

The first step consists in the analysis of overall decision making processes and the definition of possible challenges. Hereby the main steps and generic structures of decision making processes with focus on decision theory and decision support systems (DSS) were reviewed and analysed. Challenges were identified by reviewing use cases from industry, research and literature referring to information and knowledge transfer, integration of multiple perspectives, consideration of roles, identification and handling of knowledge in decision making processes and existing visualization and analysis tools. In the next step main roles and perspectives from research and industry were identified. Examples for typical roles are: designer, manager and systems engineer. Typical perspectives are: technical, organizational and personal [1]. The third step comprises the collection of descriptive criteria by realizing a throughout literature review. In step four the identified criteria were

structured, grouped into topic groups and filtered according to the requirements of the decision situations considered.
To be able to handle the identified criteria the embodiment within an application process is very important (step five). For an improved handling the criteria were integrated within a template. This template highlights a generic character and can be applied independently by one perspective or role at a time. In step six the generated decision criteria template was applied within four different decision situations in the area of architecture design and product development at BMW. In the last step (step seven) the knowledge and insights gathered from the application of the template are used for the development of perspective-dependent action guidelines. Steps four to six will be described in more detail in the following.

3.1. Decision criteria template design

41 different descriptive criteria for decision situations were collected from literature. The descriptive criteria were grouped within topic groups and allocated to the main four process steps of the decision process (see figure 1).

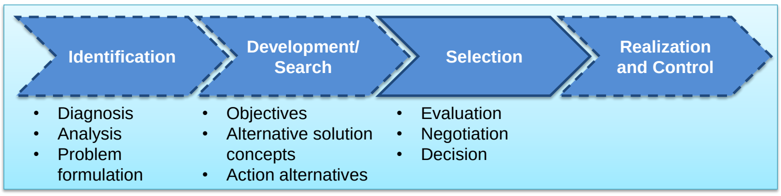

Figure 1. Decision process steps after Laux et al. [14] and Meixner & Haas [15]

To enable a better handling of the decision criteria template the number of considered criteria had to be reduced. For this purpose the criteria were evaluated according to following main questions:

- Is the content of the considered criterion covered by the used modeling notation (here business process modeling (BPMN) representation?
- Is the considered criterion relevant for the analyzed use case?

The first question covers the aspect if information can be collected at all within the realized process analysis. This is highly dependent of the information that was gathered during the 17 realized interviews in various departments. By applying the second question it is assured that by choosing a specific criterion important topics of the development process are considered. In conclusion from the range of 41 collected descriptive criteria 25 criteria could be selected which fulfilled both questions stated. In other use case analysis situations at other companies with different decision situations involved and different levels of information and stakeholders the content of the template will look differently.
Figure 2 displays the design of the decision criteria template. Hereby the exact and detailed representation of the criteria structure with integrated process steps, topic groups, allocated decision criteria and criteria values are represented. The template is designed as a standardized form which can be used by different stakeholders with different perspectives to describe and evaluate decision situations. For the first step of the overall decision process (figure 1) following topic groups could be identified: starting basis, decision maker and decision object. These elements describe the initial situation and involve all tools, knowledge and information blocks which are relevant or available for the decision making process.
A description criterion for the starting basis is the availability of information and has the value available, partially available or not available. The decision maker can be a single person (manager, designer) or an entire committee.

Process phase	Topic group	Decision criteria	Value / Characteristic			
Identification	Initial situation / Input	Information availability	avaliable	partial avaliable	not available	
		Validity, transferability, frequency, repeatability	unique	occasional	continuous	
		Tool support, IT-information	IT-only	IT-support	no IT	
		Ressources (availability)	available	sufficient	insufficient	missing
	Decision makers / Roles	Number of decision makers	single	collective (communities)	number	
		Entitlement, decision competence	missing, preparative	partial, thematically	partial, amount	full amount
		Affiliation, representation area	functional design	geometrical design	system design	manufacturing design
	Decision object / Decision situation / Options / Alternatives	Number of partial decisions, iterations	number			
		Time criticality / level order (only for partial decisions)	simultaneous	succsessive	iterative	
		Number of alternatives	number			
		Project reference	project specific	project overall	project lifecycle overall	
		Time reference	phase-oriented	overall		
Development / Search	Results / Objectives / Consequences / Output	Influence areas	number			
		Concerned disciplines	functional design	geometrical design	system design	manufacturing design
		Number of solutions	number			
		Impact time period, time range	short-term (operative)	middle-term (tactic)	long-term (strategic)	
		Decision area (concerned areas)	component / function	project / full vehicle	product line	entire company / product lifecycle overall
		Structure, interconnectedness	concurent	complementary	indifferent	
Selection	Evaluation criteria	Technical selection	functional design	geometrical design	system design	manufacturing design
	Decision procedure	Urgency, decision time	sufficient	urgent	critical	
		Evaluation of alternatives, selection	negotiation	personal opinion	analytical evaluation	hierarchical / escalation
		Tool support for decision situations (software systems)	necessary	applicable	not applicable	independent

Figure 2. Decision criteria template design

The decision object is described as the element of decision. The development and search process step comprises the topic group objective and solution.
This topic group describes the identified solutions during the solution search phase. Evaluation criteria are hereby the number of effects or impact and the interaction and interdependencies of generated solutions. The selection process step was divided into the topic groups evaluation criteria and decision procedure.
The evaluation criteria describe the aspects which are relevant and important for the evaluation of a solution within a specific decision situation. The decision procedure describes the precise procedure of selection. The template is completed by examples for each criterion so that template users can decide more easily.
In addition to the evaluation of decision situations an influence matrix was developed. Within an influence matrix criteria can be compared pairwise and criteria interdependencies as well as single criteria causes can be detected. The generated influence matrix is displayed in figure 3 (the matrix must be read by following consensus: line is influencing column).
Within the influence matrix the influence of each criterion on other criteria is documented. By realizing this pairwise criteria comparison unidirectional and bidirectional dependencies can be depicted.

From the influence matrix the active sum (sum of entries within one line of the matrix), passive sum (sum of entries within one column of the matrix) and the criticality (product of active and passive sum) and activity (division of active sum to passive sum) can be calculated. The active sum marks the number of criteria that a single criterion influences. The passive sum marks the number of criteria by which a single criterion is influenced. The criticality can be seen as a value for relevance. If a criterion highlights a high criticality then it is highly relevant for the considered decision situation [16].
The activity was not considered in the analysis of the four decision situations. The influence matrix has been applied to prioritize the decision criteria considered within the decision situations analyzed within the company. In this way the most critical criteria can be analyzed first and adequate action guidelines developed.

↗ Has influence on

● Reciprocal influence

	Level of information	Transferability, repeatability	Number of partial decisions	Concerned disciplines	Number of solutions	Impact time line, time range	Decision area	Structure, interconnectedness	Active sum	Passive sum	Criticality
Level of information			↗	↗	↗		↗	↗	11	8	88
Transferability, repeatability	↗		●						3	6	18
Number of partial decisions		●			↗		↗	↗	11	4	44
Concerned disciplines								↗	6	7	42
Number of solutions				↗		↗	↗	↗	4	4	16
Impact time line, time range		↗		↗			↗	↗	13	3	39
Decision area	↗			↗				↗	8	7	56
Structure, interconnectedness									4	9	36

Figure 3. Decision criteria influence matrix

3.2. Decision criteria template functionality

By filling out the template information and knowledge from different perspectives can be collected and compared. According to the prioritization of specific perspectives and the challenge that has to be overcome in a certain decision situation the knowledge is transferred between stakeholders. The involved decision makers can benefit from the knowledge and experience of many different views and are able to make informed long-term decisions with a wide multi-perspective knowledge base.
To be able to classify a decision situation by using the criteria template following procedure has to be realized. First information is gathered and visualized regarding the considered decision situation. In our case information was collected during interviews with employees from different departments which are involved in the use case. The representation of the use case was realized as a process model in swim lane and BPM Notation.
The gathered information comprises: roles, perspectives, decision situations, tasks, transferred knowledge and information and used tools and documentation. The use case will be presented in detail in chapter four of this paper. The situation is now structured, described and evaluated gradually according to the steps embedded within the template. Finally the described influence matrix is searched for criteria interdependencies. Hereby criteria are analyzed which highlight a high criticality and therefore a high relevance for the specific decision situation.

Within the template the knowledge of several perspectives regarding the same decision situation can be documented and transferred. From the integration of various perspectives different descriptions of the same decision situation can result. By using the template, similar decision situations from different projects or use cases can be compared with each other. “Similar” in this context means that the same product is developed but with other stakeholders involved, in a different timeline, within a different project. Similar decision situations can also involve different projects with similar results. The result is a transfer of knowledge and information between different projects and the initiation of knowledge reuse. Furthermore critical situations can be identified from the realized comparison and a decision prioritization can be realized.

4. Decision criteria template application

The use case analysed describes the development of the vehicle physical electrical system and the development of the vehicle wiring harness. The electrical system represents the physical connection of all electrical and electronical components integrated within a vehicle. The connection comprised by cables and wiring ensures the supply of components with power and the communication of integrated bus systems.
The components are for example actuators, sensors and control units. The vehicle power supply topology comprises the logical component connection.
The physical power supply represents the actual hardware. Hardware involves hereby cables, wires, fiber optics, connectors, clips, cable tunnels, wrapping tapes and safety. The wiring system is divided into audio, high-voltage, cockpit and auto body wiring system. Furthermore two building types of the wiring system are defined:

1. <u>The gradual wiring system</u>: comprises the initial design of the wiring system. The gradual wiring systems are developed independent of customer requirements and choice. In every vehicle the highest degree of wiring system is integrated.
2. <u>The customer-specific wiring system</u>: is specific to every developed vehicle. The customer-specific wiring systems comprise only wires which are actually connected to components and are requested by the customer.

Cost- , weight and functional issues are the main factors which are used for making decisions regarding which type of wiring systems is developed and integrated within the vehicle. Within the development of the vehicle wiring system many different decision situations exist with many stakeholders involved.

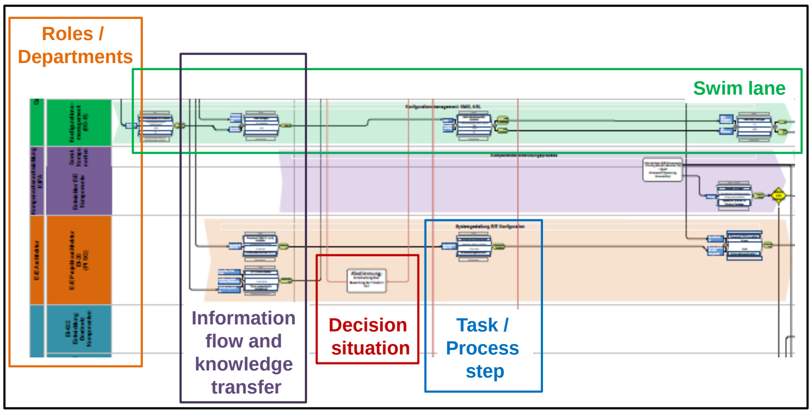

Figure 4. Wiring system process model (extract)

The swim lanes comprise the activity tasks of one department or role within a department. The process model incorporates: roles, action tasks (process steps), milestones, information and knowledge transfer flows, decision situations and used tools and resources. Within the process model several different decision situations were identified and visualized. To apply the decision criteria template a small number of decision situations were selected for the analysis. The selection of decision situations is made on the basis of following two selection criteria:

1. Information regarding critical decision situations collected from the realized interviews and the recorded or visualized development process.
2. Processes which highlight interdependencies within the analyzed use case environment.

Considered interdependencies are for example the influences on product architecture and on the wiring system development process and influences on other vehicle development projects. The application of the described two selection criteria lead to the selection of four critical decision situations. The main characteristics of the four decision situations are displayed in table 1.

Charac-teristics	Decision situation 1: Pinning coordination	Decision situation 2: Connector selection	Decision situation 3: Package coordination	Decision situation 4: Ticket acceptance
Perspectives	Process, Organization, Data	Organization	Organization, Function	Time / Phase
Tools and visualizations	Process model, system circuit diagram, organization diagram, pinning list	Process model, connector development data basis, communication flows	Process model, role structures, cross section representations	Process model, information flows, ticket transfer structure
Challenges	• Parallel information flows • Limited tool support • High amount of changes • High coordination effort	• High coordination effort • Limited information transfer • High development costs • Outdated tools	• High coordination effort • Late cross section reservation	• Time pressure • Limited coordination and communication • Limited information
Solutions, action guidelines (objectives)	• Assurance of pinning information availability • Avoidance of parallel information flows • Pinning data basis development support	• Coordination effort reduction • Development cost reduction by consolidation of the wiring system building set system	• Communication improvement between wiring system developers and the geometry dep. • Early cross section definition and reservation	• Improvement of communication knowledge transfer between stakeholders • Improved development planning

Table 1. Critical decision situations within wiring system development at (extract)

For the analysis of the four decision situations following perspectives were considered: process, organization, data, function and time/phase. The five perspectives were applied on the four selected decision situations. Hereby knowledge between perspectives could be transferred by applying the template. Also action guidelines for dealing with the challenges identified could be derived. The decision maker in case not only receives tailored action guidelines but also support consisting of various tools and visualizations. The tools and visualization are chose depending on the role and perspective addressed. The process perspective for example receives a process model visualization. A collection of offered tools can be found in table 1. From the displayed four analysed decision situations the decision situations “pinning coordination” and “connector selection” are described in more detailed in the following.

4.1. Decision situation 1: pinning coordination

The pinning coordination was chosen as a critical decision situation according to the two criteria described in the previous chapter. The situation highlights a high relevance within the context of the analyzed use case. The challenges regarding the pinning process were identified during the realized interviews.

The three calculated decision criteria with the highest criticality: level of information, decision area and number of partial decisions from the influence matrix (see Figure 3) were integrated in the analysis of the decision situation. The critical decision criteria play a major role in the identification of challenges and the development of action guidelines. For the generation of the system circuit plan specifications about the required pinning are necessary. Pinning describes hereby the procedure of planning and realization of wiring component connections. The pinning information is collected in pinning-lists.

There are three main roles participating in the pinning coordination process: the component developer, the pinning manager and the circuit system planner. The component manager fills out the pinning lists and collects information about components. The pinning manager controls entries and changes within the pinning lists and requests the completion of missing information. The system circuit planner realizes the component crosslinking coordination.

For the analysis of the pinning coordination decision situation three perspectives were considered: process, organization and data. The organization perspective involves the three described roles and the information and knowledge flows in between. Due to uncertainties regarding precise data flows the data perspective was integrated. By using the data perspective the data and information which has to be used can be detected from corresponding documents. The data has to be generated new within the pinning coordination process.

This leads to a high amount of parallel information flows. By applying the decision criteria template the actual status of the pinning coordination process could be represented.

Following challenges could be identified:

- Consistent information transfer has to be guaranteed despite of parallel information and communication flows and frequent changes (decision criterion: level of information)
- High coordination effort between component developers and limited information transfer (decision criteria: decision area and level of information)
- Definition of change management communication paths, pinning procedures and roles (decision criteria: decision area and partial decisions)
- Limited IT-support (decision criterion: level of information)

From the stated challenges following objectives for dealing with the pinning coordination process can be derived:

- Coordination effort reduction
- Insurance of pinning information availability on time
- Establishment of defined process flows and avoidance of parallel process flows
- Development of a pinning data basis

From the results generated due to template application following action guidelines could be derived:

- Process support by pinning data basis development. Information transfer improvement between component developer, pinning manager and system circuit planner.
- Parallel information flow reduction by clearly defined and visualized information flows as well as clearly defined responsibilities. The pinning information is collected in one data basis but different individuals are responsible for content management.
- Improved IT-support

4.2. Decision situation 2: connector selection

Connectors represent components which link the vehicle wiring harness with electrical components. The linkage is realized by the component developers. The connector selection is realized by the connector developers. The connector developers search within the data basis for an adequate connector. If no connector exists a new one has to be developed. The connector developers do not know where and in which extent the connectors are integrated within the vehicle. The results are organizational and planning challenges and a high coordination effort. The connector selection decision situation was chosen due to the high costs and importance within the development of the wiring system. The connector development process has a high impact on the production process due to the development and production of new connectors on demand. The critical decision criteria: level of information, decision area and number of partial decisions from the influence matrix (see Figure 3) are also used for detailed analysis within this specific decision situation.
For the application of the decision criteria template an organizational perspective was generated. This perspective visualizes the communication paths between connector and component developer. Due to the high number of utilized components a similar high communication and information transfer effort as for the pinning coordination process is observable. The effort for new connector development is also very high. The connector developer has a limited overview over utilized connectors because he has no data basis where the usage of connectors is documented.
From the application of the template following challenges could be depicted:

- High workload for the component developer induced by a high amount of inquiries and parallel development tasks. Many new connector developments within new product lines (decision criterion: partial decisions).
- Difficult information provision for component developers due to IT systems which have been set up and enhanced over long terms for increased vehicle demands (decision criterion: level of information).
- High development costs and time for new connectors (decision criteria: decision area and partial decisions)
- Connector release has influence on production (decision criterion: decision area)
- High coordination effort (decision criterion: decision area)

From the depicted challenges following main two objectives could be defined:

- Coordination effort reduction by enabling access to connector data basis for component developers
- Development cost reduction by establishing a connector building system

For the connector selection decision process following action guidelines could be generated:

- Enabling of component developer access to the connector data basis
- In case that the access for component developers is not possible or relevant a new company role can be the adequate solution. The role proposed is a connector developer integrated in every product line of a vehicle. Within the product line the connector developer processes all connector-related requests and has the task to implement a high connector reuse and a minimization of new connector development.
- Connector building set system generation
- Reduction of connector development effort and costs

5. Discussion

The developed decision criteria template was applied for the description and classification of four critical decision situations. The decision situations were evaluated by multiple perspectives and therefor information and knowledge from different views on the same decision situation could be collected.
The template served also as a knowledge transfer tool between decision makers and decision makers and decision knowledge providers.
The four decision situations could be described and missing information was added by realizing an own research as well as several interviews with employees which were active in the four decision making processes.
The described decision situations highlighted the main challenges embedded. This information is very important for the development of adequate action guidelines to help decision makers make informed decisions and have the main challenges permanently focused. The generated action guidelines were in the end presented to the decision makers of the four decision situations selected and tested regarding relevance and applicability as well as possible realization. The use case considered has a high relevance for the company because it contains a high improvement and cost reduction potential.
One of the most interesting results of criteria template application was that involved decision makers obtained insights from other different perspectives which opened them new opportunities for solution generation and decision making as well as process improvement.
A direct knowledge transfer and a better process understanding could be realized in this case. The process model induced a transparent representation of decision situations.
The developed action guidelines represent general information and solutions to cope with the stated challenges of the four critical decision situations within the wiring system development use case. In summary the main challenges identified are:

- High coordination effort due to a high amount of involved stakeholders and processed data
- Number of iterations
- Limited IT-support and limited access to available information and resources
- Definition of responsibilities

On the basis of identified challenges following objectives were formulated and tested:

- Improved information provision and IT-support
- Enabling access on relevant resources
- Enabling system transparency by detailed process and decision situation description
- Generation of necessary and reduction of obsolete coordination processes
- Definition and reallocation of responsibilities
- Definition of process flows

Regarding the application of the criteria template only a single perspective can be captured at one time. New insights and solutions could be detected or developed by combining different perspectives or specific perspective constellations. Now existing combinations must be derived by comparing the templates of different perspectives manually based on personal experience and knowledge.

The three research questions stated in the introduction chapter of this paper were addressed in detail. It could be proved that decision situations can be used as a basis for knowledge transfer within a company by generating a standardized form, the decision criteria template, for decision situation description and therefor for knowledge acquisition and transfer between company roles.
The decision criteria template can be used as a tool for knowledge transfer between stakeholders effectively. Critical decision situations can be depicted by applying decision criteria with high criticality, calculated with the help of the influence matrix (see Figure 3).
The critical decision criteria help to classify the decision situation as being critical or non-critical. Multiple perspectives can be integrated and aggregated to generate knowledge transfer and well-founded decisions by using the decision criteria template. The template can be filled out by different roles with different perspectives. The aggregation and transfer of knowledge and the generation of action guidelines are done at present manually. Hereby systematical procedures are going to be provided in future work.
The stated objectives regarding template development could almost be completely fulfilled. With the developed criteria template multiple perspectives on similar decision situations can be captured and integrated within decision situations. The transfer of information and knowledge as well as the communication flows could be improved considerably. The results from the application of the template and the comments and feedback gathered underline this statement. The decision situation transparency could be improved and also it's structuring and documentation.
Due to time constraints only the generation of innovative decisions within an interdisciplinary environment could not be completely evaluated.
The analysis of product innovation improvement by using the template as a multi-perspective and interdisciplinary knowledge transfer tool represents a long term process which will be part of our future research.

6. Conclusions

The developed decision criteria template represents a method for collecting information and knowledge from multiple perspectives involved in the same decision situation. The decision situation in case is described from different views. Challenges and critical aspects of the decision situation analysed can be detected and the decision situation prioritized according to its criticality. The decision criteria described represent a collection of decision situation characteristics. The interdependencies between decision criteria were captured by using an influence matrix.
Hereby all criteria are compared pairwise with each other. Combinations of decision criteria can be used for the identification of challenges within a decision situation. Action guidelines for overcoming stated challenges as well as short- and long-term objectives can be developed.
For the application in other companies other criteria must be selected and therefore another set of combinations has to be derived and their interdependencies analysed. The development of action guidelines is at this moment done by using personal knowledge and experience. A support of this process by the development of an adequate method is part of our future work.
Future work encompasses also a more detailed analysis and integration of perspectives. At this time only a single perspective can be analysed at one time. The collected knowledge is aggregated by comparison of the filled-out templates and decision making solutions.

Combination of perspectives would give us more detailed insights about the decision situation analysed and provide better solutions for critical decisions. The developed template must also be applied in further companies in order to observe its applicability and limitations.
By integrating various perspectives within critical decision making processes the knowledge transfer process can be improved and also the generation of well-founded decisions supported.

7. Acknowledgement

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