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STRATEGIC PLANNING FOR MODULAR PRODUCT FAMILIES

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ABSTRACT
Highly customised products mostly lead to increasing complexity for the production company. Two common design approaches for reducing the internal complexity of a product family are Design for Variety and Modularisation. However, in many application cases it is desirable to consider an optimisation of the variety already in the product planning phase affecting a wide range of products. The approach presented in this paper uses a representation of both the structure of products and economic key figures. Using this method, different strategic scenarios of the product program can be planned and compared to each other. The derivation of strategies for the future and their evaluation is performed using key economic figures and the technical conceptualisation of platform components.

Keywords: Modular Product Families, Product Planning, Variety Management

1 INTRODUCTION
For improving competitiveness, costs and flexibility, most production companies have a more or less applied variety management. An important focus of variety management is the early phases of the product development process as this is where the most influence on an optimised product structure can be achieved. An approach for strategic planning and optimisation of a company's product range is presented here. The methodical procedure defines the products and their variants with a focus on platform design. In subsequent development phases, the product structure will be elaborated further using Design for Variety and Life Phases Modularisation.

2 BACKGROUND
In the product creation phase, variety management basically has two strategies: variety generation and variety avoidance (Figure 1) [5]. Variety avoidance means optimised product design to avoid unnecessary technical variety of parts or assemblies of the products. Variety generation contents steps towards the definition of the product variants. Variety generation is part of the product planning phase and determines the input required for the product development phase.

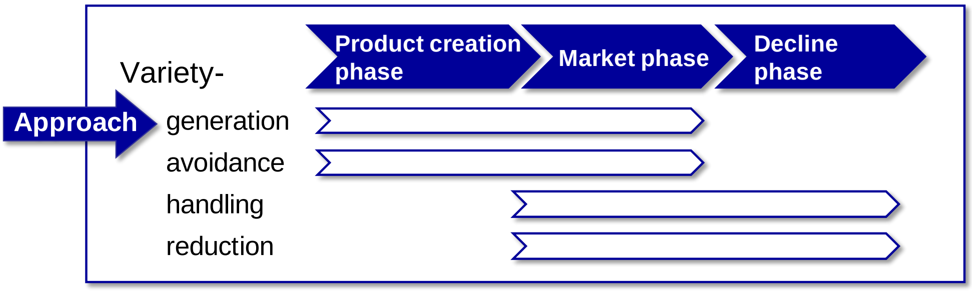

Figure 1. Phases of Variety Management

Often companies tend to plan and develop product families independently from each other, which hinders the use of synergies, e.g. by use of common platform modules. Therefore this paper gives an approach for methodical platform planning considering the future development of the whole product program.
The approach gives systematic support for variety generation (product planning phase) and its interaction with the methods of variety avoidance (product development phase). Therefore, the current methods for variety avoidance next will be investigated. Common methods in this context are modular

design and Design for Variety. Modular design is not necessarily a sub-domain of design for variety, because modularity can support various development aims, such as after-sales or purchase. Modular design is widely used to reduce internal complexity with a modular configuration which generates external variety with only a few basic assemblies. Basic modularisation approaches consider technical-functional [8] & [9] or product strategic perspectives [3]. In technical-functional approaches, matrix systems are often used to cluster the components of the product according to their interdependencies. A modularisation method that considers the life phases of the product is presented in [1]. The core of the method is the Module Interface Graph (MIG), which visualises different modular designs of a product according to the phases of the product life. In a merging step, the life phase perspectives are integrated into a final design. Figure 2 shows a Module Interface Graph in example of an aircraft galley [1] [6].

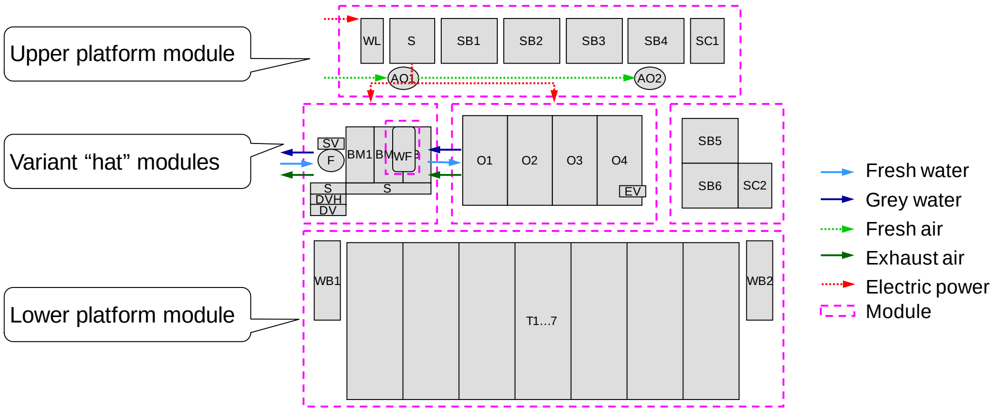

Figure 2. Module-Interface Graph (MIG) of an aircraft galley

A Design for Variety approach is described in [7] [2]. Central to the approach is the Variety Allocation Model (VAM), a four-layer model of differentiating attributes, variant functions, variant working principles and variant components. Using the VAM, the actual product structure is investigated and will be optimised for the ideal configuration of 1:1 mapping of differentiating attributes to variant components. Figure 3 is an example of the Variety Allocation Model [2].

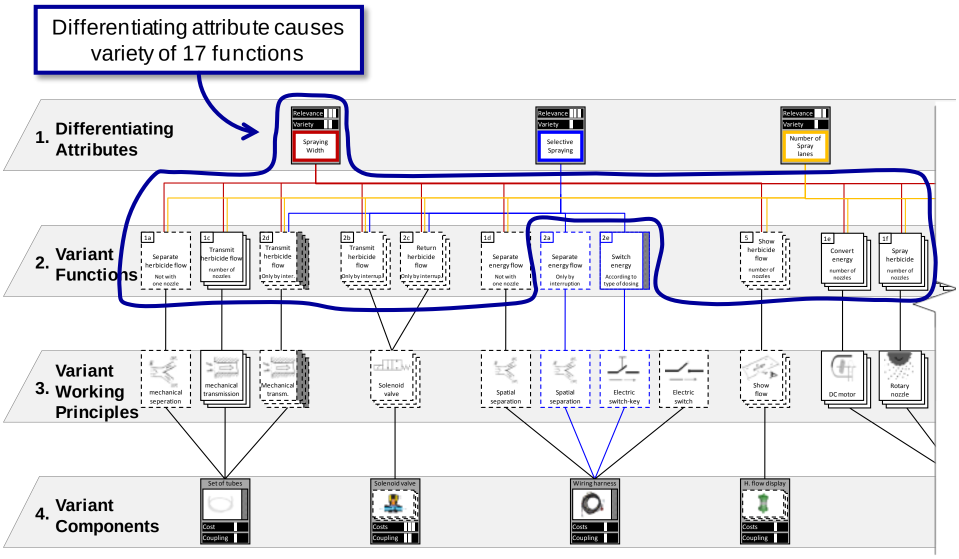

Figure 3. Variety Allocation Model

The Design for Variety approach described above can be used in combination with the Life Phases Modularisation method. This allows the design optimisation of the components (VAM) and the module definition visualised by the MIG. However, this procedure is only applicable to smaller product families. A product family is understood here as being a sum of products that share common parts and functions and operate in similar market segments [4]. For many application cases, it would be useful to enhance the described approach with an investigation of the whole product program. This would allow the development of platform approaches for more than one product family. Figure 4 is an integrated approach for developing modular product families, which consists of a sequence of the three elements Product Program Planning, Design for Variety and Life Phases Modularization. The elements of Design for Variety and Modularization operate at the product family level. The element of Product Program Planning prior to these defines the variety and implements strategic platforms into the program. The methodical approach of Product Program Planning is the focus of this paper and will be described in the next sections.

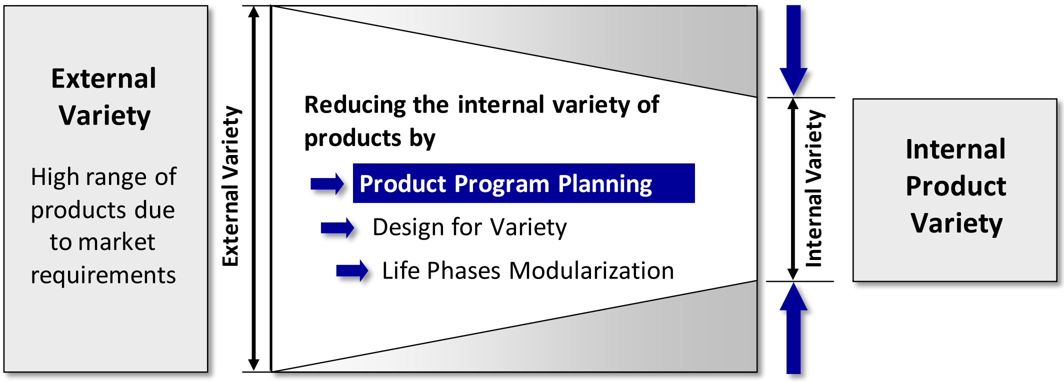

Figure 4. Integrated Approach for development of Modular Product Families

3 APPROACH FOR PLANNING PROGRAM SCENARIOS

This section describes the approach for the variety-optimised planning of the product program. Section 3.1 presents a visualisation tool that uses a representation of both the product structure and economic key figures. Section 3.2 gives heuristic support for generating projections for the future structure of the program. These projections are compared to each other by using the visualisation tool presented. Section 3.3 describes an approach for evaluating the scenarios developed. The basis for the evaluation is the conceptualisation of strategic platforms. Due to the fact that different program scenarios generate different possibilities for using strategic platforms and carry over modules, the use of economic key figures supports the assessment.
Chapter 4 gives an example of practical application of the method.

3.1 Development and Visualisation Tool for Product Programs

For the strategic planning of product program scenarios, a tool is needed which represents the products and their hierarchy and offers economic key figures. In contrast with pure mechanical design, the product planning phase is less constrained and so future scenarios of the product program can be better evaluated if economic information is included. Figure 5 presents the developed tool.
In contrast to a classical tree structure, the two dimensions of angular increment and radial length are used to show information about number of units and sales revenue of a product section. They can either be actual values of the current state or estimated values for the future. Using this visualisation tool and based on the running business, new scenarios for the future structure of the product program can be derived, visualised and evaluated. The product program can be restructured in different scenarios using platform and carry over parts, together with an update of the business strategy.

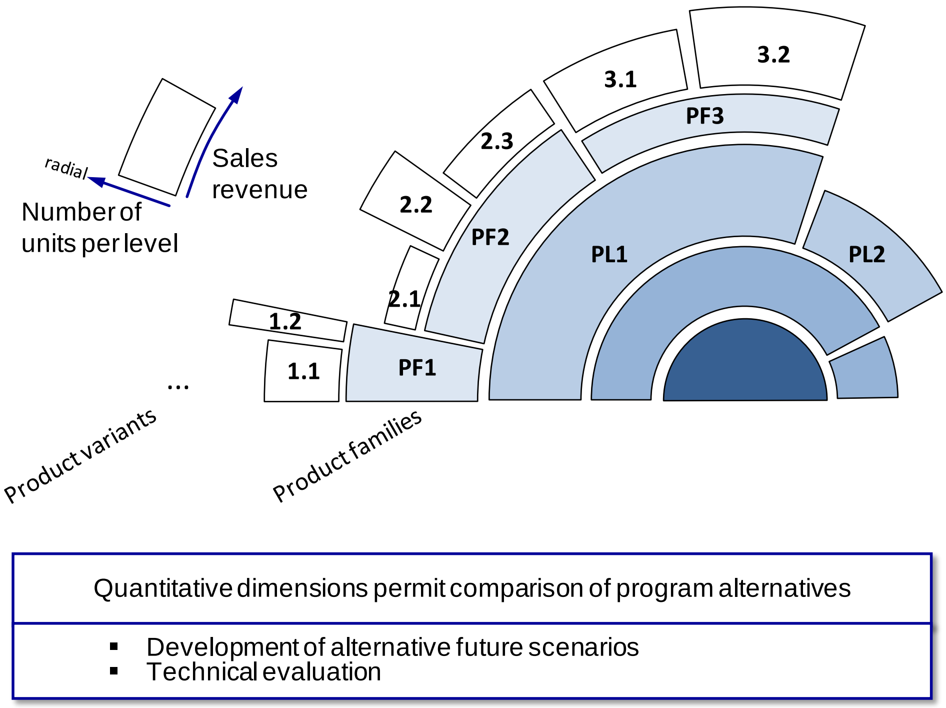

Figure 5. Visualisation tool for the Product Program

The use of quantitative elements in this visualisation creates a quick overview of the basic configuration of scenarios of the product program for the development team, allowing comparison of alternatives for the product planning. Changes can be made on different levels of hierarchy, either changes for the complete program near root level or minor changes near product level. The next section gives heuristic support for the creation and manipulation of strategic product scenarios. Following this, Section 3.3 describes an approach for evaluation.

3.2 Derivation of Scenarios

According to [12], the development of a product program of a company can be categorized into one of four major types. These types can coexist in one company, for example, where products have different technology cycles.

- Type 1: *Custom Engineering:* The product portfolio is based on continuing growth. New products are developed and added to the portfolio in response to customer enquiries. Cuts to the product range are not necessarily made routinely.
- Type 2: *Release Engineering:* The product portfolio is based on constant width and regular updates. The market constantly forces readjustment of the portfolio. This causes routine new product approvals and product eliminations.
- Type 3: *Variety Maintenance:* The product portfolio remains nearly constant. The company uses an active standard of products with only few changes over the time.
- Type 4: *Basic-type Engineering:* The product mix is based on innovation. The market demands new, innovative products. The variety of products is mainly influenced by the dynamic of the market.

To apply the method presented, the product program first needs to be classified with the help of the development types shown. Application of the method is particularly meaningful in the case of the development types 2 and 3. In the case of Release Engineering, regular product eliminations and new positioning need to be developed. Therefore, the method presented gives an overview and common language for the development teams.
In the next step, strategies for the actual changes that need to be made to the program will be derived. The portfolio analysis, known as the BCG Matrix [10], assigns the products of a company according to their dimensions Market Growth and Relative Market Share (Figure 6). Stars have high Market

Growth and Share, but typically demand high investment costs to maintain growth. When Market Growth slows down, Stars change to Cash Cows and become an important source of support for other business units. Cash Cows have a high Market Share but slow Market Growth. Cash Cows generate high revenues at typically low investment costs. Question Marks have a high Market Growth but low Market Share. Due to the high growth, they need high investment and even more effort to increase their low Market Share. It often needs to be clarified whether high investment will be performed in the hope of a shift towards the Star-type or whether disinvestment would be the better choice.

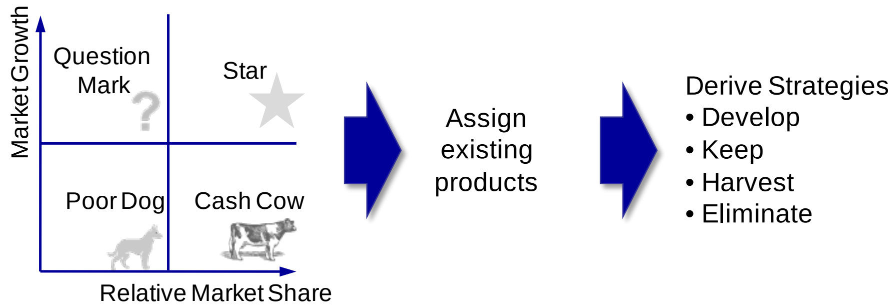

Figure 6. BCG Matrix for deriving product strategies

Once the products of the company are assigned to the BCG Matrix, strategies for structuring the future program can be derived. According to the type of product, i.e. Question Mark or Cash Cow, and the assumed market development, the following strategies for change to product families can be considered [11]:

- *Develop:* This strategy aims to increase the Market Share of the product unit. The strategy should be applied to Question Marks that are promising and are therefore a candidate for investment towards becoming a Star.
- *Keep:* This strategy aims to keep the Market Share of the unit at its current level. The strategy should particularly be applied to successful Cash Cows to maintain good revenue into the future.
- *Harvest:* This strategy sets the focus on short-term revenue of a product without considering long-term development. Application can be meaningful particularly for weak Cash Cows that have less promising market prospects. Question Marks and Poor Dogs can be candidates for this strategy too.
- *Eliminate:* Using this strategy, unsuccessful products or business units are to be sold or closed. The strategy is mostly applied to Poor Dogs or unsuccessful Question Marks.

Application of these strategies will lead to changes in the resulting variety of the product program. The tool shown in Figure 5 represents these planned changes. An advantage of the overall visualisation of the product program is that different scenarios can be compared to each other on the same graphical level, even when changes are made to independent units. Figure 7 gives an example. Based on the current product program (Figure 5) alternatives for the future structure of the program are shown. Questionable in the given example may be Product family 1 (PF1), with relatively low revenues, and Product 2.2 of Product family 2 (PF2), also low revenue and high number of units. A conservative approach could be using “Variety Maintenance” and merging Product 2.2 with the remaining products of PF2. A more radical solution could be the elimination of PF1 and a restructuring of PF2, including a new product in PF2 that replaces some essentials of the eliminated PF1. This comes under the strategy of “Release Engineering”.

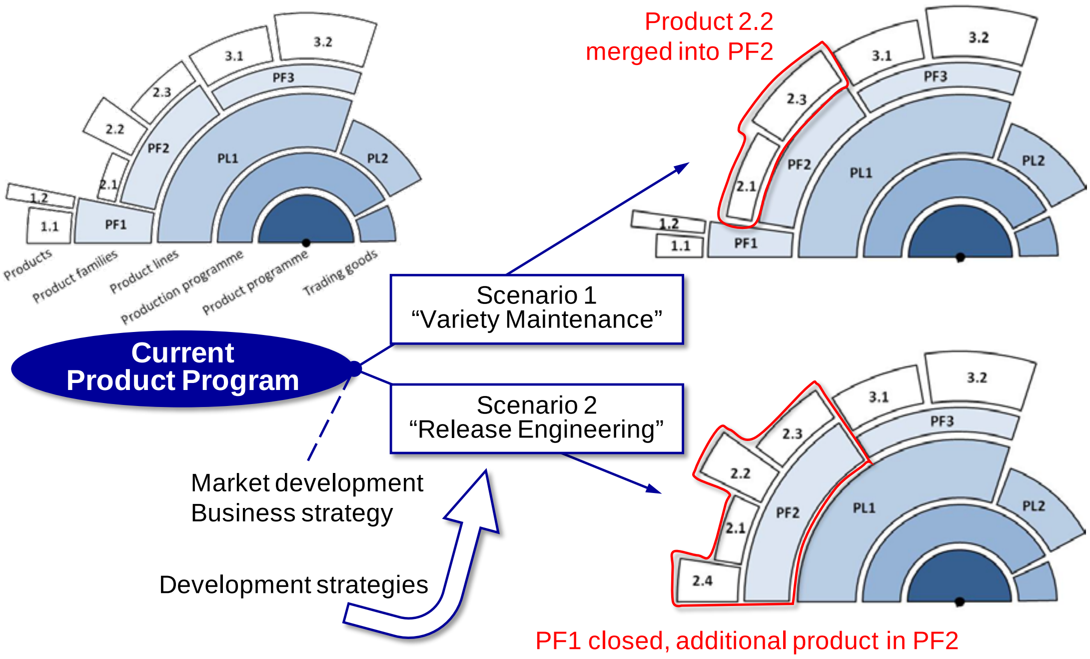

Figure 7. Example for Scenario development using different strategic approaches

Using the visualisation tool, scenarios for the future product program can be developed based on different strategic approaches. In the example given, scenario 2 would be particularly meaningful if the portfolio analysis identified PF1 as a Poor Dog or unpromising Question Mark. Using the same method, profiles and competitor scenarios can be investigated and then mapped towards the company's prospects. This may help to identify market niches or promising segments. The company scenario projections may then incorporate this competitor analysis.

3.3 Evaluation of Scenarios

As in Section 3.2, alternative scenarios for the future structure of the product program have been developed. In the next step, the scenarios need to be assessed to each other. This will be performed by an investigation of the potential of each scenario for supporting strategic platforms. Therefore a different representation is needed. Since the previous step showed the product level without product variants, this step will investigate the variants with respect to potential platform standardisation. Still in the phase of product planning, the economic key figures will be included in this consideration. Figure 8 shows the approach represented by a graph of the products and their assemblies. All products of a scenario, according to Figure 7, are included in a variety analysis in Figure 8. The variety of a product is visualized using differentiation between standard and variant assemblies. The question of how finely the element "assembly" here is understood must be clarified for the individual case. If "assembly" is considered too closely, for example, by singular mechanical elements, the overview will become too complex to handle. However, if "assembly" is too rough, there could be only few options become visible for platform conceptualisation.

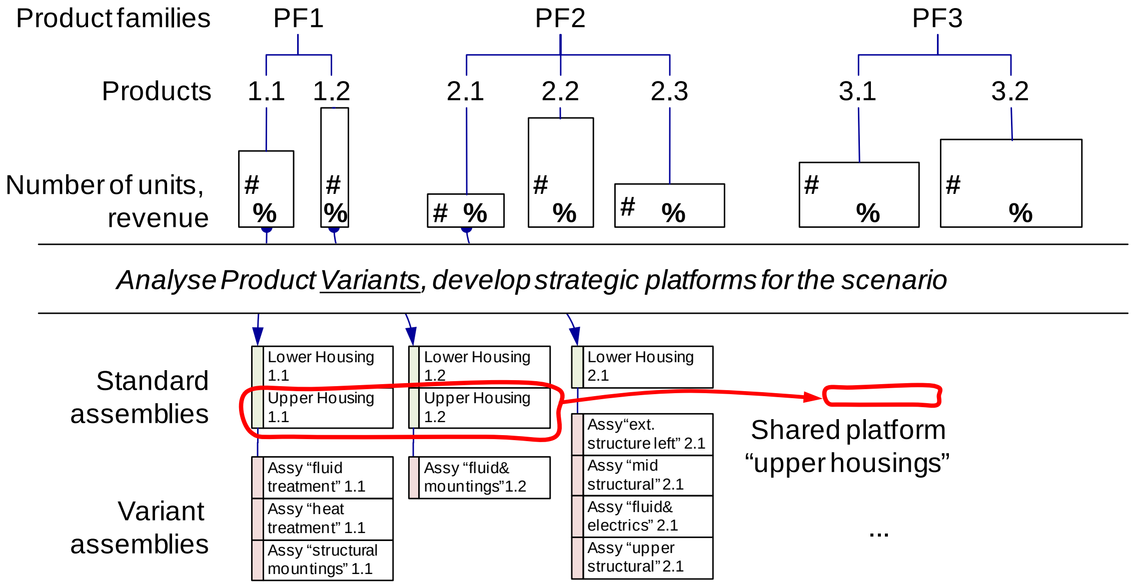

Figure 8. Evaluation approach by conceptualization of strategic platforms

After the assemblies of the products are analysed and noted into the graph, the development team conceptualises possible platform elements for the scenario. For this step, the functions and constraints of the assemblies of different products are compared to each other. The aim is to identify assemblies that commonly have the same function and similar constraints. These common assemblies are candidate for platform modules as exemplary identified in Figure 8. For support, the engineer can perform design modifications such that the assembly matches function and constraints of both products considered. The aim is to design strategic platforms that may be used in products of different product families. If a compromise needs to be made on alternative platform concepts in one scenario, the economic key figures can be assessed to evaluate the benefits of each combination.

Once platform concepts have been developed for the different program scenarios, an assessment needs to be performed to identify the most promising scenario. To support this assessment, the previously analysed economic key figures are used to estimate the economies of scale for each scenario due to the platform concepts.

4 EXAMPLE

This section outlines an example of the application of the proposed method. Figure 9 shows the product program of an aircraft cabin supplier, which was used as the basis for this investigation. For confidentiality reasons, the program is modified and contains fictional numbers. Some products are not shown. The following figures will use the same notations as Figures 5 and 7.

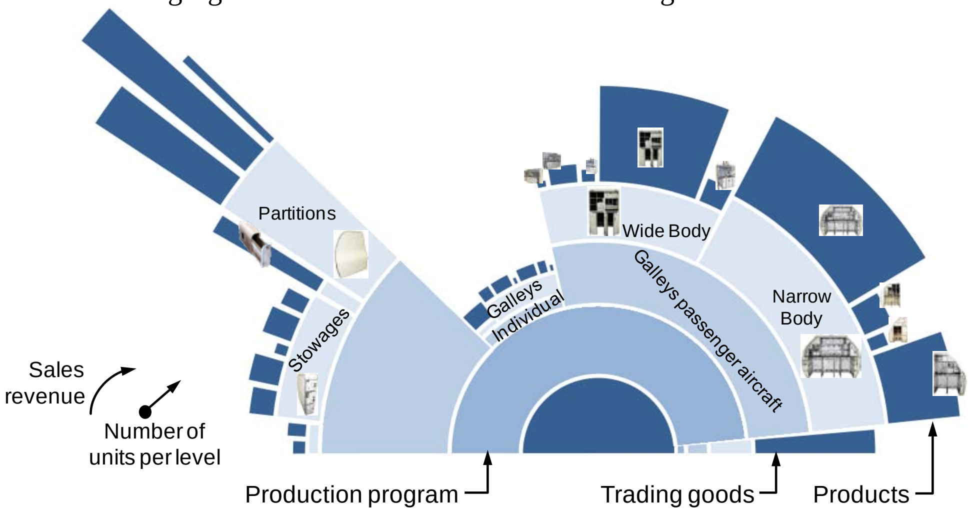

Figure 9. Exemplary Product Program

According to this product program, Figure 10 shows an interpretation of the actual condition: products 7.4 and 8.1 are essential Cash Cows for the company. Both products have high Market Shares and slow Market Development. Product Line 3 (PL3) is the core business of the company since more than the half the revenue is generated by its products. Noteworthy is product 4.3, which shows a high number of units but very low revenue. This product needs to be further investigated. Product Line 2 (PL2) shows a low number of units, but a significant share of the overall revenues. This can be explained by the fact that the company manufactures the products of this line according to individual design orders at low number of units. This causes complexity in the manufacturing division, thus a further investigation would be meaningful. The products 7.1, 7.2 and 7.3 are members of product family 7, which includes the Cash Cow, but show low numbers of units. Investigation of this will also be carried out.

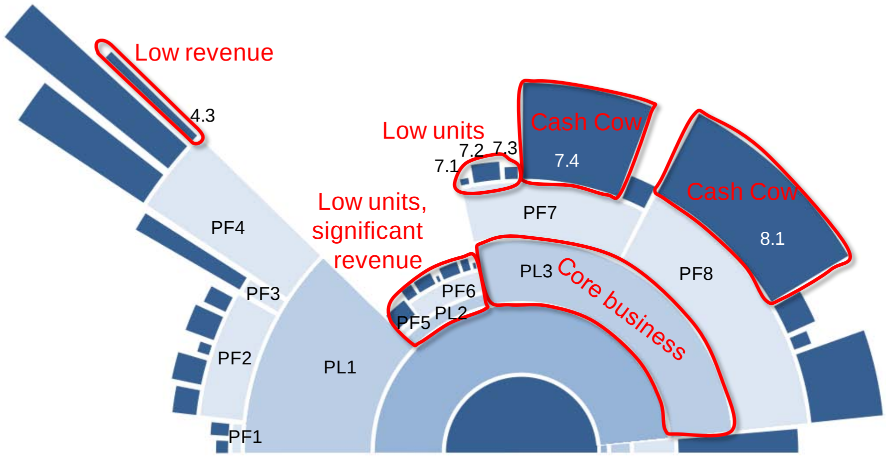

Figure 10. Assumptions regarding the Product program

The next step will be deriving strategies for future scenarios of the structure of the product program. Only one scenario will be given here as an example. In this example, investigation of product 4.3 showed that the induced manufacturing complexity is comparably high and elimination of the product might not be appropriate. Since the structure and function of the product are not of the core business, outsourcing its production was considered. Figure 11 shows the actions performed in the program; in the case of product 4.3 it was moved to the trading goods. For product line 2 (PL2), it was identified that the company offers no products to a certain customer type. A market entry is planned, represented by the new product family 5’ (PF5’). Two product families in this line that were rarely sold have been eliminated since no prospects of significant Market Growth could be detected. In the case of product family 7 (PF7), elimination of products was not a choice since they bring in revenue fairly well and are part of the core business. Further investigation of the platform design will be performed, as explained in Figure 8.

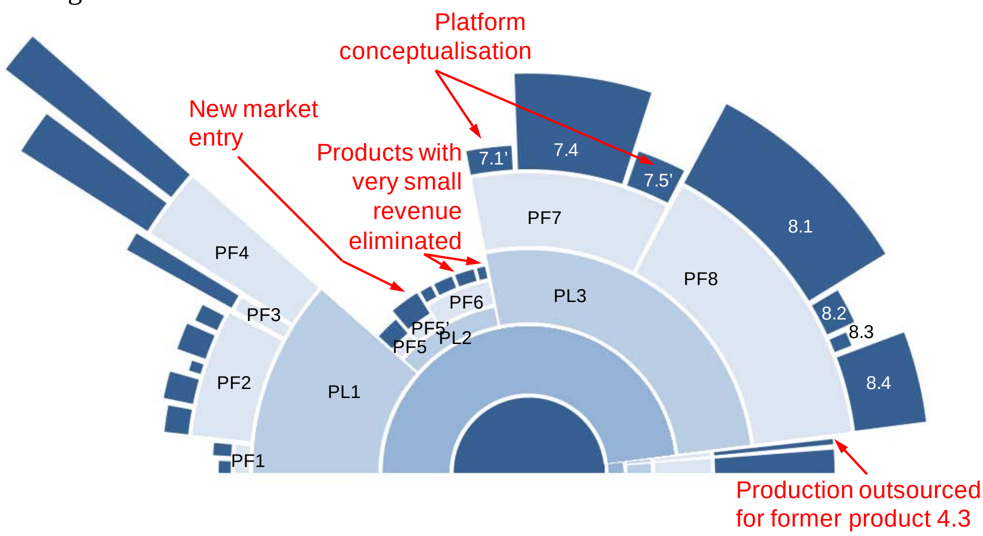

Figure 11. Scenario for changes made to the Product program

This platform conceptualisation, as shown in figure 12, lists the product families, products and their key figures. Next, the assemblies are analysed for their variety and function, as explained in Section 3.3. Using this graph, the engineer uses his product knowledge and creates platform components using assemblies that have the same function and similar constraints. To create a platform, design changes shall also be considered to fulfil the constraints of different products. These design changes can particularly involve concepts of standardised interfaces, harmonisation of geometrical parameters and, if meaningful, over-sizing. As a result, in the current example, housings and structural installations were standardised using interface and minor design changes such that the new platforms 7.1' and 7.5' were introduced.

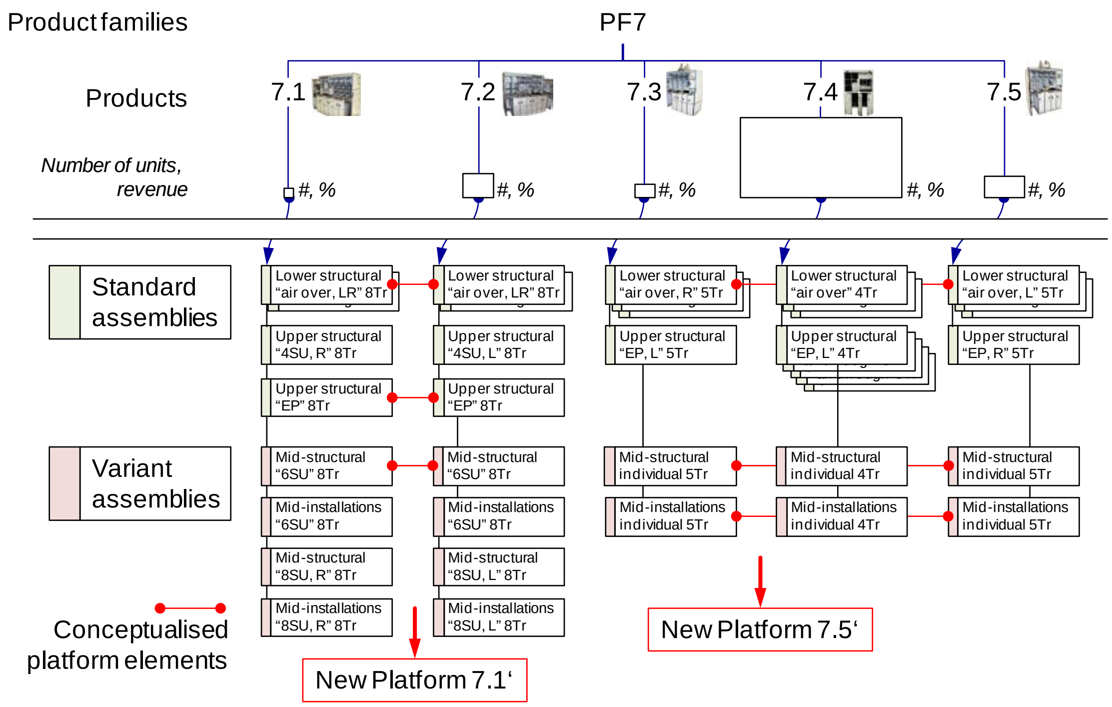

Figure 12. Variety analysis for platform conceptualisation

5 CONCLUSION

A method for strategic planning of modular product families in the context of variety generation was presented. The approach introduces a representation tool of the overall product program, visualising the structure of products and economic key figures. The development type of the company and the market positions of the products were analysed to derive change in the future program. These changes are visualised in the tool presented using different scenarios. In assessing these scenarios, possible platform systems are conceptualised and their benefits estimated. The defined structure of products and variants will be included into the subsequent design phase, where the methods of Design for Variety and Life Phases Modularization will be applied at the product family level.

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