Conceptual Full-Vehicle Development supported by Integrated Computer-Aided Design Methods

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ABSTRACT

Todayʼs automotive industry is characterized by a high product diversification in combination with decreasing times-to-market. This leads to high demands on product development processes and assumes the application of multidisciplinary and flexible virtual product development tools and methods. The present publication introduces to the challenges of conceptual full-vehicle development and discusses the ability of applying a centralized product master model by an exemplarily illustration of a 3D-CAD approach. As a key aspect of this publication, a method for the support of geometrical full-vehicle development processes (e.g. geometrical integration, vehicle packaging) during early product generation phases is presented and discussed in detail.

Keywords: automotive concept development, packaging layout, CAD master model.

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1 INTRODUCTION

Product development in the automotive industry is driven by a highly complex series of market requirements that stem from a wide range of product variances and functionalities. Stagnating sales volumes in traditional markets and increased competition lead simultaneously to growing product diversification and reduced time-to-market processes. The industrial globalization of development, manufacturing and distribution has resulted in new business models, which have to consider several market-specific factors. Changing boundary conditions from legislation and from the customer orientation, as well as a growing realization of the finite nature of crude oil supplies are spurring a reorientation of individual traffic and a consequent introduction of new vehicle concepts. The development of smaller and lighter cars driven by alternative propulsion technologies requires a revision of common vehicle concepts and will lead to the implementation of completely new vehicle architecture and styling solutions. At the same time, increasing customer demands in terms of safety, comfort and fashion trends are forcing the creation and implementation of new technologies. This technical evolution needs a reduction of investment risks throughout the entire product life cycle, which requires the consideration of production-, market- and disposal-related factors during the entire development cycle.

Development processes in the automotive industry place high demands on the performance and flexibility of applied strategies and tools. Besides the standard prerequisites (e.g. design, simulation and production engineering), a number of enhanced requirements are challenging the architects of future development cycles. Within the boundaries of a permanent cost and time reduction in engineering-based development, new strategies have to support a smart connection between the working fields of project engineers, component designers, ergonomic specialists, safety and crash departments, designers and all of the other involved parties. Nowadays, automotive development is driven by the interaction of virtual design and simulation methods in combination with physical development and testing procedures. The trend is definitely going in the direction of integrated virtual development processes which focus on the product function itself, but also take into account both the production and supplier situations, as well as lifetime-relevant factors that pertain to customer use, support, service and disposal. The increasing application of virtual methods is taking over several tasks formerly handled by physical development, which is now moving towards data acquisition and verification procedures. This has led to a significant reduction in expense of hardware-based test and prototype development in the last decades. The implementation of virtual product development methods enables a higher degree of product maturity in initial phases which simultaneously means decreasing economical risks of the entire development cycle.

Full-vehicle development constitutes a complex challenge for original equipment manufacturers in automotive industry. Figure 1 illustrates a typical full-vehicle development process which can be understood as a sequence of several process phases with different degrees of maturity of the final product. Besides the process phases, the graphic shows significant milestones during automotive development, which are representative for designation of phases. In addition, a selection of main disciplines, based on CAD, in early development phases is pictured. Generally, a new vehicle project starts with a definition phase to work out designated product specifications. In a following concept phase multiple concept variants representing different aspects related to styling, packaging and functionality are elaborated in a high level of details to support the procedure of variants elimination. Derived from the determination of a limited amount of concepts, the pre development phase not only contains the initial development of the functional components, but also the design of the chassis and therefore ergonomic investigations and geometrical integration. Main purpose of the series development phase is the detailing and verification of the predefined concept to achieve series-production readiness. The full-vehicle development phase closes with a physical pre-series of the vehicle for final product verification and the start of production.

In automotive development, the main characteristics of a new car model are determined in initial phases like the concept or pre development phase of product generation. As a part of these phases, the geometrical development of a new vehicle represents an essential field influenced by factors from several development disciplines. Key aspects in the area of geometrical development are the definition of the vehicle styling, initial packaging layout to fulfill predefined space and ergonomic requirements, and of course the geometrical integration of components and aggregates. An efficient way to handle this extensive amount of information from different working areas and to ensure an optimized geometrical vehicle development, the application of methods based on computer-aided design is indispensable.

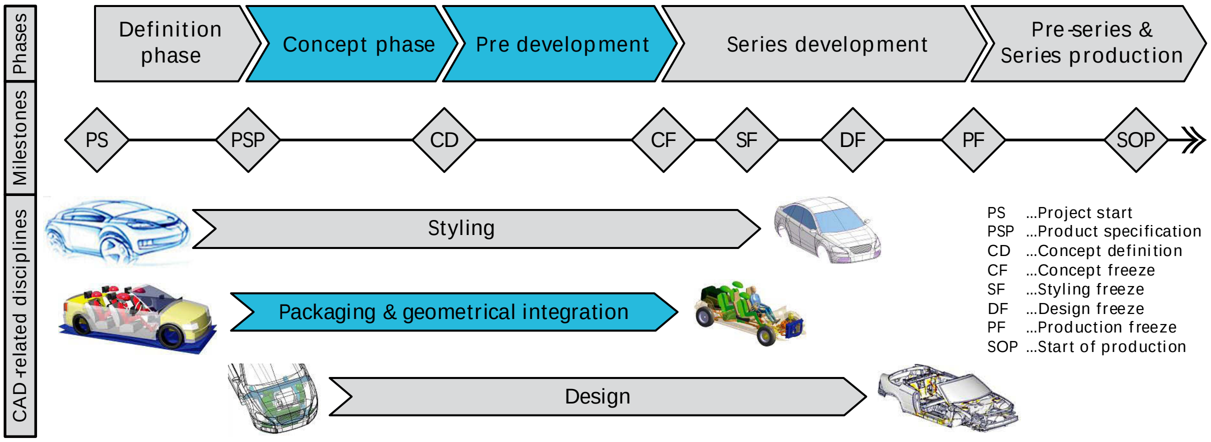


Fig. 1: Automotive full-vehicle development process, containing CAD-related disciplines.

2 CHALLENGES OF AUTOMOTIVE CONCEPT DEVELOPMENT

The main intention of automotive concept development is to ensure the feasibility regarding a cost-efficient production of a customer suitable and competitive full-vehicle concept. As a result of the concept development, several vehicle concepts with determined main dimensions are elaborated in consideration of geometrical and functional aspects within economic and legislative boundary conditions. In a final step of conceptual phases a committee discusses these variants in detail and decides their ability for further development to series production readiness, [4]. The decisions regarding the development process taken in these early phases are responsible for a significant percentage of the entire development costs. Due to this fact, a high degree of product knowledge is desirable in early phases which can be realized by integration of virtual development tools in several departments.

Automotive full-vehicle development processes start with the definition of comprehensive product specifications followed by an initial functional layout and the general vehicle package configuration. In this way, automotive concept development is characterized by manifold requirements descending from initial specifications, which have to be achieved and unified in several vehicle concepts. In the course of concept development, the level of details of elaborated concept variants is rising continuously, which leads to an increasing participation of different working areas with particular requirements. Figure 2 exemplary illustrates an extract of influencing factors in automotive concept development. In addition, the interactions respectively the dependencies of this multidisciplinary project environment are demonstrated, which leads to a complex process situation.

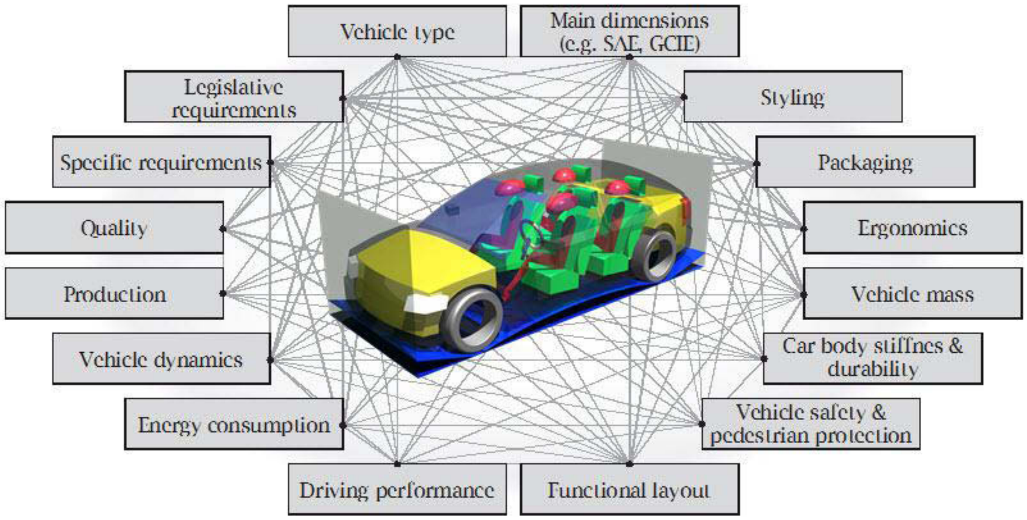


Fig. 2: Interaction of working fields in automotive concept development.

Since the conceptual definition has to consider various, partially conflicting boundary conditions and specific requirements from different development departments, the resulting vehicle concept always represents an outcome of intensive optimization processes. In general, multi-user project environments constitute high demands concerning timeliness of data and efficient preprocessing to provide valuable and meaningful detailed data. Therefore periodic synchronization procedures with regards to contents amongst the participating working areas of both, internal departments as well as external suppliers, state an essential precondition for the iterative concept development. The synchronizations of componentsí geometrical information as well as functional aspects, lead to rising degrees of maturity of the virtual prototypes in early phases. This multidisciplinary optimization requires a high flexibility from the tools, methods and processes applied, to ensure an effective data and knowledge transfer between the different departments and disciplines. In particular, the challenge for developing innovative technologies is to create a highly flexible 3D-CAD model that can help deal with numerous package variants and can enable an efficient optimization that takes into account legislative guidelines, styling and technical functionalities. In addition, it supports the consideration of the issues of drive-train configurations, energy storage systems, vehicle driving characteristics and many more. Integrated development strategies, including parametric-associative geometry creation, interlinked with simulation and computation procedures, have to be applied to fulfill the requirements of the multidisciplinary working packages in early development phases.

3 CAPABILITIES OF CENTRALIZED 3D-CAD MASTER MODELS

In modern virtual product development of complex products, and especially in automotive engineering, a trend towards to fully defined 3D-CAD master models as central product representation and data pools is emerging. The reasons for following such strategy in automotive industry are manifold and mainly caused by the collaboration of a considerable number of development process disciplines in combination with modern simultaneous engineering processes. The realization of these master models in 3D-CAD environment is based on the fact that the product itself continuously is in focus of the entire product development process. On the other hand it supports the anthropogenic constricted spatial sense, to exemplary act as a basis for discussions. These master models not only contain geometrical information but also function- or production-related metadata. A centralized comprehensive data repository allows the efficient archival storage of all kinds of product information and concurrently makes a clearly structured administration available, so that sources of error, possibly originated from insufficient data integrity, can be inhibited. This fact in combination with the possibility of efficient data tracking enables centralized master models to satisfy the presented requirements of early development phases with respect to the mentioned amount of concept variants. In addition, the implementation of such a process-integrated method can lead to the reduction of individual working effort related to coupling of design and simulation disciplines, by exemplary supporting them to provide a common data status and consequently to ensure reproducible development results. Furthermore, this configuration of a 3D-CAD master model interacting with centrally arranged, flexible data storage accomplishes the continuously enhancing requirements during the entire product development process by achieving the designated knowledge transfer from concept to series phase. Therefore a higher degree of maturity can be reached in an early development phase which leads to detailed data with a high level of quality in following phases. The emerging demands on the CAD architecture in terms of rising level of product details and a decreasing degree of parameterization by a proceeding development process, assume the implementation of a subordinated data management structure which ensures a higher flexibility in contrast to conventional PDM systems.

Generally, automotive concept development has high demands on these integrated virtual development methods, however simultaneously they offer a wide range of possibilities. In this way, rapid and confident evaluations of concept variants based on qualitative design and simulation results are ensured to be performed. Master model configurations constitute a potential basis for digital mockup and further working disciplines, thus they will represent a main role in complex, virtual development processes in the future.

4 APPROACH OF MULTIDISCIPLINARY COLLABORATION IN CONCEPT DEVELOPMENT

Regarding the discussed range of possibilities using centralized 3D-CAD master models in automotive development, an approach including the implementation of an integrated full-vehicle model for the improvement of conceptual automotive development is presented in this chapter. Further detailed information of this approach is treated in several publications [2], [7-10], [12].

A weighted selection of the processes in concept- and pre-development phases is linked to a comprising virtual car model in order to connect the different fields of early development. To ensure their partly divergent requirements in view of geometrical and functional aspects, the present virtual concept tool is composed of several sub-modules which are separated related to different factors e.g. location of vehicle components or matter of validation. Figure 4 illustrates the general architecture. The concept tool consists of its interlinked main modules, like a centralized data repository, a function module and a comprehensive geometry module, which are divided into the mentioned sub-modules. Generally, the product visualization is performed by the geometry module within modern commercial 3D-CAD software, using integrated, parameterized templates (sedan, station wagon, pickup, etc.) as frame geometries to support a quick generation of first package concepts. Additional sub-modules enable the representation of styling shapes, the continuously growing digital mockup (DMU) as well as ergonomic investigations and packaging layout. Sub-modules concerning parameterized geometry to support the geometrical investigations and surfaces deviated from legislation boundaries to check the according vehicle concept regarding the homologationʼs point of view are also part of the geometry module. Based on the 3D-CAD representation, a further sub-module allows a user-comfortable definition of sections, exemplary for the creation of two dimensional package layouts and dimension concepts. The far reaching geometrical integration process enabled by the considerable capabilities of this sub-module is specified in the following chapters. Besides the function of visualization, the integrated 3D-CAD model especially supports the conceptual development by offering verification tools for geometrical and technical validation.

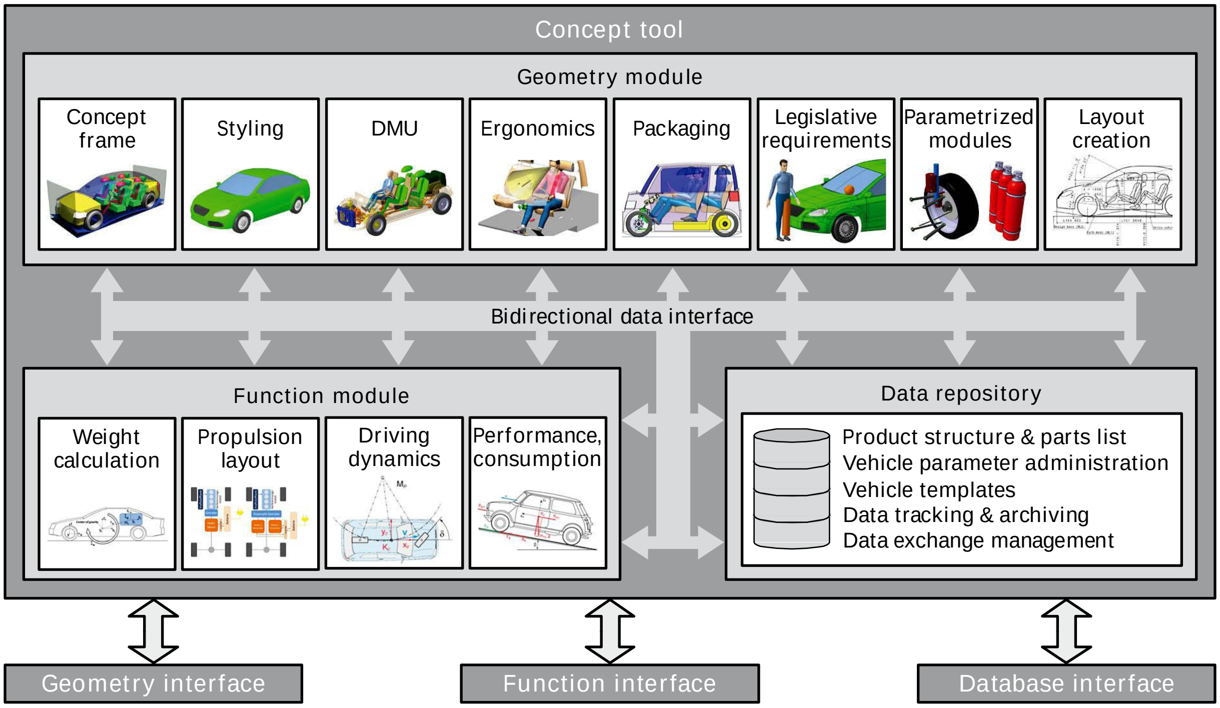


Fig. 4: General architecture of the virtual concept tool, cf. [8].

As part of the concept tool, a powerful data repository contains all information required by the participating disciplines of automotive concept development, varying from geometrical parameters to legislation based information. To sustain the high demands of flexibility, the parameters of the database are user-defined expendable and generally supported by a graphical user interface. A bi-directional connection between the 3D-CAD model and the database enables a parametric geometry control, as well as a tracking procedure and data archiving to record rapidly changing data status of a multiple amount of vehicle concepts. In addition, the database interface permits modifications and variant studies of the geometry by users who are not primarily specialized in the applied design software. Thereby the concept tool provides direct access to the relevant information on vehicle geometry. In this way, the database represents the point of intersection of simultaneously development procedures, information exchange and optimization cycles. A separate function module is directly connected with the data pool and with the geometry module. This module consists of several functional-oriented sections, which exemplary enable an early estimation of the overall vehicle weight, the determination of driving performance and fuel consumption, as well as the simulation of primary vehicle dynamics in consideration of different propulsion layouts.

During processes of geometrical integration, as described in the following chapter, the application passes through diverse sub-tasks of packaging and layout, virtual ergonomic investigations, verification of legal requirements, the generation of a dimensional concept and the definition of a mass package. From this it follows, that the conceptual product model is modified and assessed simultaneously by different departments under numerous conflicting viewpoints. Depending on their varying necessities, adequate modules of the virtual concept tool are used. Consequently, the present approach supports an efficient multidisciplinary collaboration, respectively a knowledge transfer between several involved development departments and suppliers. For example, the development of full-vehicle packaging concepts requires the collaboration of a packaging department, specialists for legislation based boundary conditions, ergonomic development departments, as well as component and module suppliers. A so called vehicle architect plays a central role in the conceptual full vehicle development, which is responsible for the overall layout, the integration of styling and an efficient integration of all involved parties. The data flow between these multiple disciplines, but also concurrently performed general tasks, like project management, workflow management and cost calculation, to name just a few, can be managed and supported by the presented approach of a centralized virtual concept tool.

Resuming the considerable amount of functionalities, initial development phases can be delivered with significant results due to the process-oriented integration of styling, design and simulation in the presented virtual concept tool. The implemented parametric-associative 3D-CAD vehicle model enables a quick geometrical validation of changing input parameters, originated from a diversity of concept variants. In this way, the main demands of automotive concept development can be structurally unified and achieved in consideration of the toolös own closely linked data management. As discussed in a previous chapter, a main challenge in virtual product development is the transfer and reuse of knowledge. Therefore, the concept tool offers several possibilities of import and export interfaces to constitute an efficient integration to existing development environments and to traditional PDM systems.

5 GEOMETRICAL INTEGRATION IN FULL-VEHICLE DEVELOPMENT

This chapter points out relevant information of the geometrical integration process in automotive concept development, which is circumstantial treated in common literature, [5-7], [14].

One main procedure in conceptual full-vehicle development deals with the packaging layout and the geometrical integration. This procedure, which is also known as packaging process, addresses the geometrical arrangement of vehicle components, as well as the definition of passenger space and luggage compartment. In automotive engineering the package itself describes the geometrical dimensions and the spatial layout of components and aggregates inside of a vehicle, by use of graphical representations in consideration of design-related boundary conditions which are mainly derived from the desired product specifications. In this way, the package manages and meshes the demands on installation space, ergonomics and the overall vehicle characteristics, in collaboration with the participating working disciplines. The packaging process, as an inherent part of modern virtual product development, can be understood as an overall geometrical product validation, [3]. Simultaneously it serves as a geometric-technical interface between the working areas and therefore itös mainly responsible for the coordination of the full-vehicle architecture. Starting with a general diversity of concept variants in early concept phase, the amount of package alternatives is continuously decreasing until reaching the concept freeze milestone, which often takes place in series development phase. In general, the aim of a modern packaging process is the elaboration of a coherent and validated vehicle package according to the requirements coming from sales and distribution, results originated by marketing research and ergonomic aspects. Of course, the created packages are influenced from production-related point of view to exemplary enable a clash-free positioning respectively assembling of components.

In earlier times, the packaging process was driven by the technical requirements of drive train, chassis and other mechanical components. Present key disciplines like passenger space and ergonomics were often seen as a secondary target. Figure 5 shows a packaging drawing of the Steyr Type 30 from 1930. This drawing contains the arrangement of technical components, but no seat dimensions or other passenger-related components are included. In those days, automotive manufacturer handled the vehicle platform development, and coach production companies built the car body. With this practice, it was difficult to achieve an efficient interaction between the **ò**technical side**ó** and the **ò**passenger-related side**ó** of car development.

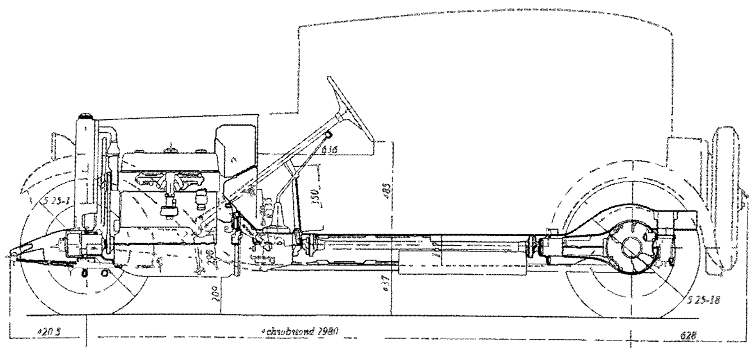


Fig. 5: Packaging layout of the Steyr Type 30 from 1930, [11].

Nowadays, the geometrical integration starts with the definition of passenger requirements. The important facts are the entrance area, seating position, head and elbow clearance and the accessibility of control units. The car type has a significant influence on the seating position. Exemplary, there is a noted difference between the development of a sports car and that of an SUV. In addition, the target markets influence passenger space requirements too. All of these factors have to be considered from the early development phase on and define the vehicle characteristics in general. Figure 6 shows a dimensional layout of a modern car. A large number of dimensions are visible, which characterize the interaction of technical components and ergonomic viewpoints. The main vehicle dimensions are prescribed in several standards, e.g. the SAE-standards or the GCIE-standards [3, 13].

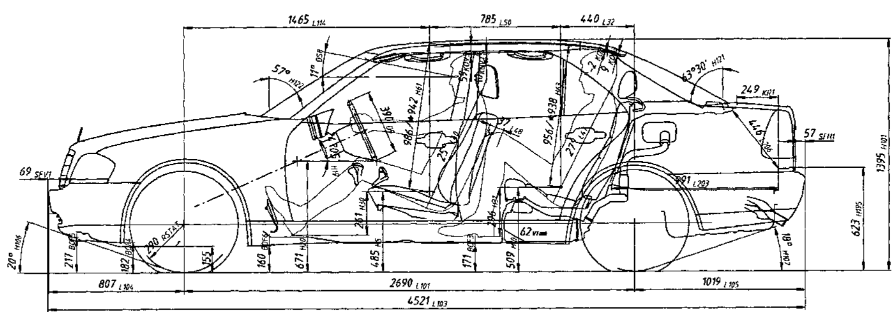


Fig. 6: Packaging layout of a modern car, [1].

The geometrical investigations are performed within the boundaries of targeted comfort- and space requirements, vehicle dimension definitions and technical module space necessities. In addition, the vehicle styling demonstrates a significant influencing factor by limiting the available installation space. In this way, aesthetic shapes and technical demands are consolidated during the packaging process until reaching the project milestone of styling freeze. Subsequently emerging tradeoffs between these disciplines are mainly affected by product specifications in consideration of brand-related intentions.

A variety of legislation-based boundary conditions significantly influence the entire concept phase. These conditions affect geometrical dimensions, crash and safety-relevant features as well as view and lighting equipment. Several ergonomic characteristics are prescribed closely related to these safety concerns and have an effect on the basic vehicle layout. In the concept phase, the targeted vehicle class provides the general layout of the seating position in each row, the number of passengers and the arrangement of luggage space. Besides these principal decisions, brand-specific boundaries influence the ergonomic layout. The seating position and the passenger space are important physical factors. All of these ergonomic elements influence the layout of the door entrance area, the opening angle, the handling of the trunk cover and others.

In modern product development processes, the basis for the packaging layout and geometrical integration is a 3D-CAD model structure, which contains all geometry data as well as simultaneous interfaces to several disciplines. These required characteristics compared to the initial elucidated capabilities of centralized 3D-CAD master models, highlight the suitability of the previously introduced multidisciplinary approach to accomplish the demands of the geometrical integration.

Figure 7 illustrates an exemplary workflow of a modern package development, which is performed by use of the presented approach. A conceptual automotive development can start with the definition of packaging-relevant vehicle data, which correspond to the requirements of the specification table. This process includes the representation of vehicle main dimensions through appropriate parametric boundary surfaces and geometrical elements in the 3D-CAD model. An additional implementation of predefined components and human models enables the definition of an initial full-vehicle packaging concept. Sources for predefined components or modules can be existing vehicle models (e.g. predecessor models), geometry data pools or simplified 3D-CAD models. The presented virtual concept tool's own data base includes a selection of predefined elements, such as internal combustion engines, electric motors and parametric dummies for different energy storage systems, as well as a sub-module for the implementation and conceptual representation of suspension systems, as shown in Figure 4.

The integration of envelope geometries from external sources, simplified predefined components and the representation of boundary surfaces for the vehicle dimensions in one 3D-CAD model leads to an early and efficient setup of a conceptual full-vehicle model. This concept model provides the basis for further investigation and optimization cycles, which deal with the interactions of components, vehicle dimensions and space requirements of passengers, as well as an early estimation of the storage concept. Therefore, DMU processes, such as component positioning, clash and distance analysis or sectioning functionalities assume a significant role in the packaging process. During this process, the particular development status can optionally be exported as a two dimensional layout, derived from the 3D-CAD model to facilitate discussions and synchronizations amongst all involved departments.

These dimensional layouts in shape of 2D-drawings of the vehicle concept are created to evaluate the package related to predefined dimensions and to serve as a basis for decision preparation and release definitions. The dimensions of these drawings are standardized to support the exchange of geometrical information between the participating development departments. Depending on the development progress of the entire product, a variable amount of geometrical information is available with different level of details. In this way, the entire packaging process is an iterative workflow reaching from a coarse initial dimensioned concept layout to define the general vehicle dimensions, up to a comprehensive full-vehicle layout considering all necessary components. The procedure of generating these vehicle layouts, in particular the dimensioning of the 3D-CAD geometry, emerges as a time-consuming and cost-intensive work which has to be performed several times. In the following chapter, a method to support the extensive creation of dimensioned vehicle layouts is presented. This method is based on an integration of automated derivation of two dimensional layout drawings from the integrated 3D-CAD full-vehicle master model.

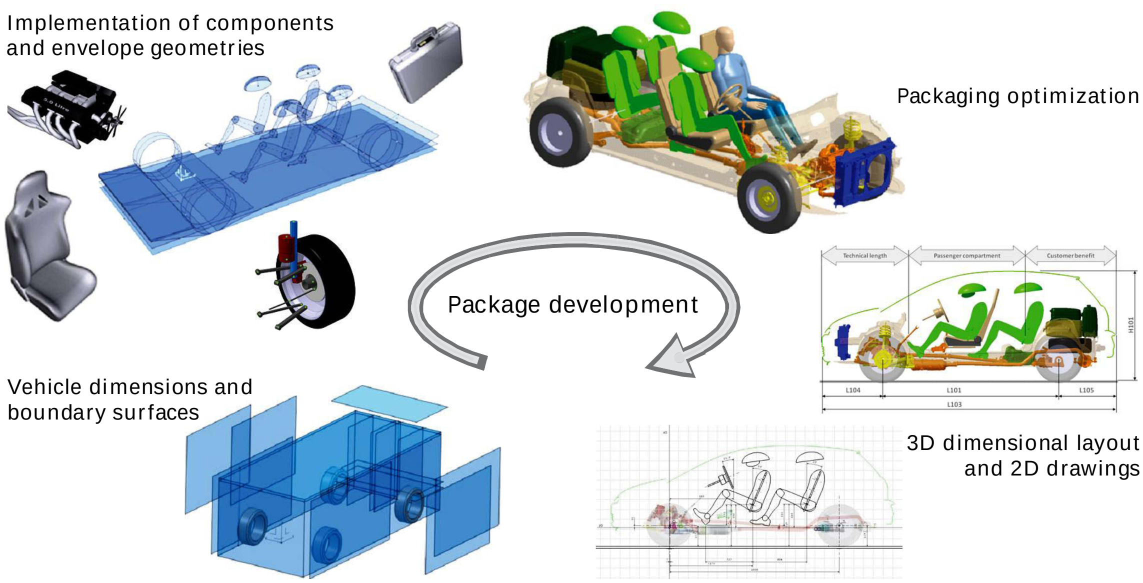


Fig. 7: Generation and optimization of a full-vehicle packaging concept, cf. [2].

6 AUTOMATED CREATION OF DIMENSIONED FULL-VEHICLE LAYOUTS

The presented method enables an efficient derivation of 2D-drawings including an automated geometry dimensioning and positioning of a predefined information table (e.g. title block) on demand. In this way, the introduced process below is able to facilitate shorter development cycles and simultaneously supports efficient full-vehicle development processes in automotive industry.

An overview of the workflow of the method is shown in Figure 8. Generally, the following procedure is related to 3D-CAD data, like a comprehensive DMU, or alternatively to a centralized master model, as previously introduced. In this way, a user-defined exchange of the geometry source is enabled. Subsequently, the imported geometry has to be defined regarding the requirements of the measurement algorithm. After the definitions of these design features, the actual automated routine starts. In some circumstances multidimensional CAD geometry has to be intersected or projected, to ensure a stable application of the following mathematical routines. The performed algorithms are predominantly based on mathematical extremal value analyses. These routines obtain the references for the actual measures. The measurement process itself closes with the dimensioning within the 3D-environment, using these references. As an output of the automated dimensioning procedure, a dimension concept of a full-vehicle layout is created.

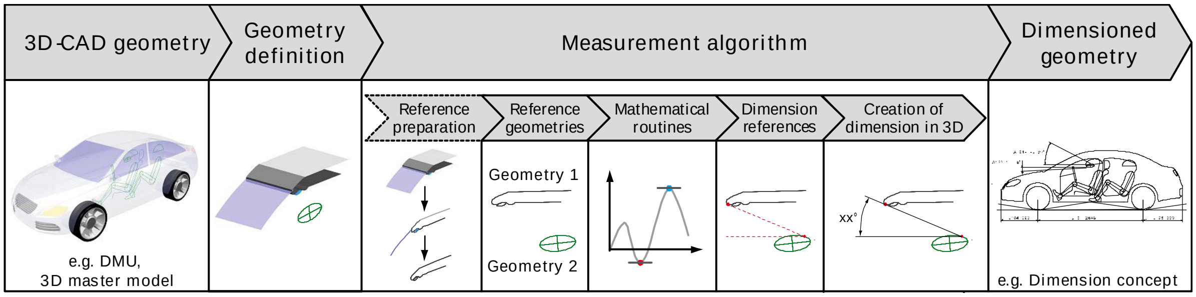
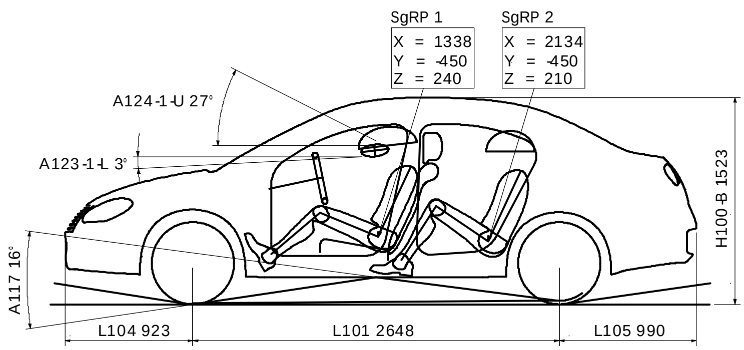


Fig. 8: Overview of the process.

In particular, the procedure deals with the automatic creation of overall vehicle layout drawings. The vehicle dimensions are created under consideration of diverse standards. The most common standards are included in GCIE and SAE guidelines, [3], [13]. The definition of GCIE standards is based on the requirements for the improvement of manufacturing data exchange. SAE Recommended Practice originally defines a set of measurements and standard procedures for motor vehicle dimensions. Both standards are complementing but also enlarging one another and thus they serve as comprehensive dimensioning standards for the dimensioning and measurement of a vehicle. Various OEM (Original-Equipment-Manufacturer) use different dimensioning standards to represent their vehicle dimensioning depending on the particular vehicle size and type. The measurements described below refer to the nomenclature of GCIE definition. Figure 9 (a) exemplary illustrates a full-vehicle dimension concept containing a selection of GCIE-related dimensions.



GCIE definition	
SgRP 1	...Seating reference point driver
SgRP 2	...Seating reference point passenger
A124-1-U	...Vision - forward up of driver
A123-1-L	...Vision - forward down of Y-plane
A117	...Ramp angle at maximum load
L104	...Overhang front
L101	...Wheelbase
L105	...Overhang rear
H100-B	...Vehicle height - body

Fig. 9: (a) Full-vehicle dimension concept, and (b) extract of GCIE definition.

The geometry, which serves as a basis for the dimensioning algorithms, is represented by a section of the 3D-vehicle geometry. In general, the sources for the geometry can be in terms of any CAD data. In case of full-vehicle engineering, it can selectively stem from the previously described master model in conceptual development or from a full-vehicle DMU with detailed geometrical information. In this way, the procedure can be performed independently or in combination with the introduced virtual concept tool. The created geometrical references serve as a basis of subsequently performed dimensioning in 3D working space by the use of adequate workbenches of modern parametric-associative 3D-CAD systems. Depending on the measure definition in GCIE standard, the dimensioning references are set by implemented mathematical algorithms of common CAD systems. These procedures are usually applied to 2D-sections, but also to 3D-surfaces to ensure stable automated routines.

In the subsequently presented example, the reference settings for a selected dimension algorithm are explained in detail. This example is representative for all other types of dimensioning. For a closer look, a specific measure was chosen in reference to the eyellipse. This measure describes a part of the field of view of the driver. The characterized measure relates to the GCIE standard and is designated as the value òA124-1-Uó, as shown in Figure 10.

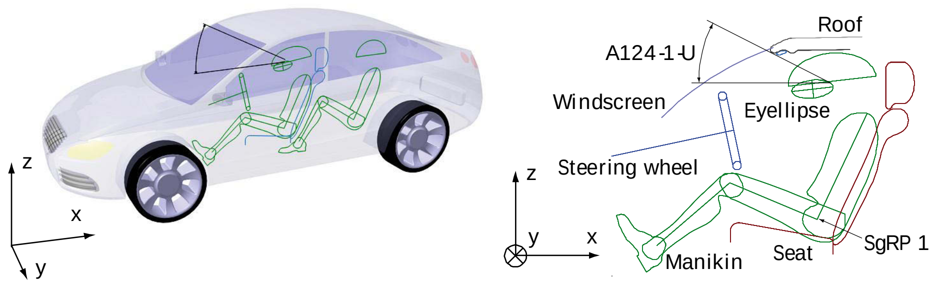


Fig. 10: Definition of the A124-1-U measurement procedure according to GCIE.

Generally, the standards do not predefine the exact value of the angle. The estimation of the angle can be arbitrarily large and is up to the OEMsõ responsibility. Besides others, it is influenced by legislative boundaries and therefore it is mainly determined by the traffic lights point of view. The specified dimension is defined as the angle between the horizontal plane and a plane tangent to the top of the eyellipse and at the same time tangent to the upper trimmed body, including all the elements that can obstruct the vision, measured at the driverõs Y-Plane, [3]. The SAE driver manikin [13], the windscreen base surface and the roof interior as well as exterior geometry serve as input data for the selected measurement algorithm.

Considering the roof contour of the vehicle, this area can be quite complex. Sun visors, but also the front end of the roof can limit the occupantsõ field of vision. In this way, the input surfaces have to be prepared for a stable measurement algorithm. One reference of the questioned dimension is represented by the tangent which contacts the roof contour in a tangency point. To obtain this desired point for the measurement automatically, a reference preparation is necessary, which is performed by sectioning the windscreen and the roof surfaces. In this case, the measurement algorithm starts with an intersection of these surfaces with a plane in the driverõs position, which orthogonal aligned to the Y-direction. Thus, a 2D-contour of the roof is created which represents one part of the reference geometry; the other part is represented by the 2D-eyellipes, as exemplary illustrated in Figure 8. The subsequently performed mathematical algorithm starts with sequent iteration steps to investigate the lowest point of the predefined roof contour. In a next step, the tangent to the ellipse through this lowest point of the roof is demanded. By application of a mathematical extremal value algorithm, a first approximation of the tangent of the eyellipse curve can be calculated. A new direction for the following iteration step of the algorithm is created perpendicular to a plane which is defined by the first approximation of the tangent of the ellipse and the Y-direction. The subsequently performed iteration steps follow the same scheme, until there is a very near approximation reached. The tangent of the eyellipse and the line in X-direction are representing the dimension references, which are used to set the required measurement.

By the help of this specific template geometry, implemented within a common 3D-CAD environment, the tool offers the possibility to create dimensioning independently of the complexity of input geometry. The user merely needs to define the specified geometry. After that step, the desired annotation of the dimensioning is set automatically. All other implemented dimensions are created with similar functions.

In the automotive industry a transition to a central 3D-master model as product representation in development processes can be observed. This offers the advantage of improved and shortened design cycles. Product teams can communicate their development and manufacturing requirements directly, and apply this information in the downstream manufacturing processes. An integrated 3D-CAD model is able to facilitate the entire product life cycle, because development relevant, manufacturing-related and material-specific information are packaged. The design, analysis, manufacturing, collaboration, inspection and even dimensioning can be done within an extensive 3D model. For a better overview, dimensions associated with the reference geometry in so-called visualization sets are defined. This feature reduces the dependence of additional 2D-drawings and provides extended possibilities within the 3D-master representation. With respect to the previously mentioned example, additional notes, and of course the dimensions themselves can be saved. All non-relevant information is not considered and displayed anymore. So it is simple to retrain an overview of manifold dimension entities.

The automated 2D-drawing creation appears as a supplementary feature of an integrated 3D-CAD master model. It serves as a base for discussions and decisions. Using the previously described visualization sets in combination with the presented tool, a vehicle layout can easily be created. The presented method also enables the possibility of additional functionalities, e.g. automated lists- or title block creation. In this way, all required supplementary information can be stored and maintained. It supports an automated filling, management and saving of title block contents and enables the linkage to CAD external data management systems. A user-friendly setup of the automated functionalities by introduction of a GUI (graphical user interface)-based handling enables a simple workflow.

7 CONCLUSION

The increasing competitive pressure and constantly shortening development time in automotive industry are forcing the implementation of new strategies and methods into existing product development processes. Subsequently emerging challenges lead to increased economic risks, which can generally be limited by an enhancement of product knowledge in initial development phases. This can be realized by the integration of virtual development methods in early phases. The present publication introduces to general characteristics and challenges of automotive concept development. In relation to these demands, the capabilities of 3D-CAD based master model configurations, as centralized product representations, in combination with comprehensive data repositories and enhanced date exchange interfaces are presented. In addition, an approach is introduced, which supports an efficient conceptual full-vehicle development and, amongst others, enables the multidisciplinary collaboration of several participating developing departments and suppliers. The geometric full-vehicle development process represents an essential challenge, especially in early conceptual phases. The packaging process illustrates a part of the geometrical validation and treats the geometrical arrangement of vehicle components and aggregates in consideration of legislative boundary conditions, ergonomic aspects or further function-related requirements. As a key aspect of the present publication, a method that enables the automated derivation of fully defined and dimensioned 2D-drawings, performed in 3D-CAD environment, is presented. Geometrical sources of 3D-CAD data can alternatively stem from a full-vehicle digital mockup or a master model (e.g. from the presented approach). By application of this method, labor-intensive creation of detached drawings is avoided, which subsequently enlarges the potential to focus on the core business of automotive concept development.

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