



Executive Summary

# Setting the Course for Innovative Engineering



## EXECUTIVE SUMMARY

The realization of efficient product development and production processes forms the basis for economic success. It is of vital importance to keep up with the technological development in order to be able to react to new developments in time and furthermore to actively participate in the future evolution of development related technologies. In this context, the domains of Functional Mock-Up, Collaborative Requirements Management, Collaborative Project Engineering, VR-Engineering, IT-Security in Virtual Product Creation, and Knowledge Based Engineering are of particular importance and require detailed attention. The study "Setting the Course for Innovative Engineering" has been conducted with the major objective of identifying

IT-potentials in product creation and possible realization strategies up to the year 2010. This study pays special attention to the domains mentioned above and describes comprehensively the respective states of the art, deficits and requirements, trends and visions, realization subjects and strategies, as well as benefits and success criteria. The present article summarizes the results of the study which was conducted by Fraunhofer IPK in cooperation with TU München (iwb), TU Darmstadt (DiK), TU Chemnitz (FtU), Computer Graphics Center (ZGDV e.V.), and Universidade Metodista de Piracicaba, Brasil (UNIMEP). It was kindly financed by ProSTEP iViP Association.

## FUNCTIONAL MOCK-UP

### FRAUNHOFER IPK

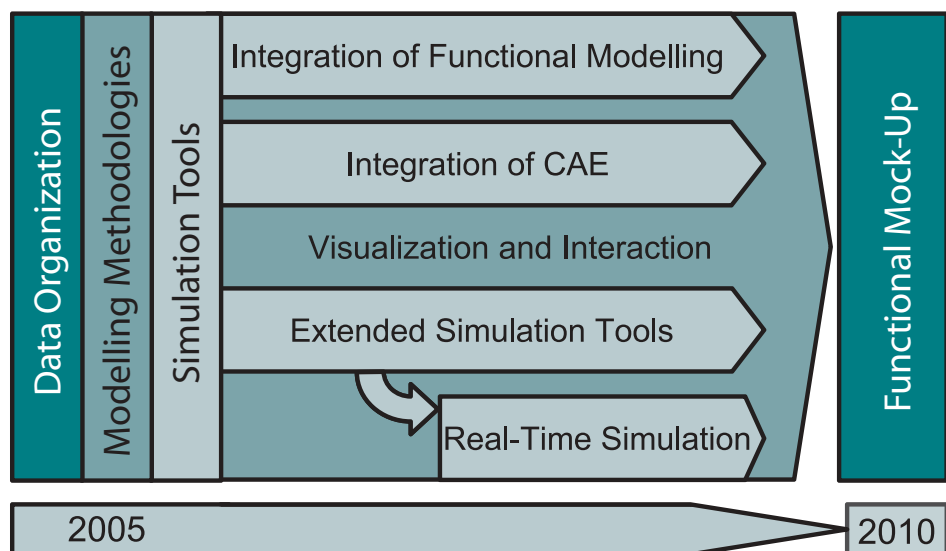
The application of Digital Mock-Up (DMU) can still be regarded as one of the crucial enabling technologies of virtual development processes. With regard to the overall objective of replacing time and cost intensive physical mock-ups by digital counterparts, remarkable results have been achieved and productively introduced in automotive and aerospace industries. A lot of current implementations of DMU are merely targeted at solving packaging problems. A prediction and analysis of product functions and operating performance features based on DMU currently lacks adequate integrated solutions. In order to validate a design comprehensively there is a strong need for new and advanced methods to improve modelling and simulating of virtual products. Uncertainties need to be handled and managed to ensure that product functions and their performance can be predicted on each stage of development. In this context Functional DMU (FMU) is a logical extension of Geometric DMU. FMU allows to represent and to examine physical and logical product properties. This, in turn, allows to overcome the current limitations of DMU and to close the gap between geometric representations and close to reality representations. This can mainly be achieved by seamlessly integrating CAE methods into concurrent development processes. Depending on the respective development stage appropriate simulation models on a system-level have to be generated and managed. In addition, the compilation and visualization of data models from different CAD and CAE

systems has to be ensured and a convenient interaction with the FMU has to be provided. Real time facilities have to be supported whenever possible, especially in Virtual Reality (VR) based interaction (figure 1).

To achieve this goal, the following realization subjects have to be addressed regarding data, data management and simulation tools: a central product reference model, extended management and handling of part properties such as functional information, kinematics, inertia in PDM, exchange and share product models on a heterogeneous platform, improved CAD-DMU-CAE interoperability, standardized file formats and interfaces, improved data quality, automated model generation, support of multi-material modelling (heterogeneous parts), etc. Furthermore, the spectrum of applicable tasks based on FMU has to be extended to provide a higher level of realism and to allow real time behaviour simultaneously. Such applications have to support the simulation of system levels based on hybrid simulation models, mechatronic design and engineering, and integration of lifecycle aspects.

Introducing Functional Digital Mock-Up into ongoing and future product development processes leads to remarkable improvements in efficiency in the entire product and production development. For example, FMU allows to achieve a higher maturity of early product development stages, reduced numbers of iterations and changes, and timeliness of data.

figure 1:  
Main development activities  
for functional mock-up



## COLLABORATIVE REQUIREMENTS MANAGEMENT TU MÜNCHEN (IWB)

Mechatronics is defined as the maximum integration of mechanics, electronics and software development within one system or component. The development process in mechatronics is characterized by the necessity to communicate continuously between the three disciplines and, alike industrial development as a whole, it needs to focus on the realization of given requirements.

With the help of a component and function based structure for requirements this necessity is likely to be met. The component view on information will mainly support the works of the mechanical engineering department, while the functional structure is basically used by electric and control system developers. A description of the system behaviour, which can be found within the functional specification, is realized by the software development department.

Likewise all specific tools for the different collaborating disciplines need to be closely linked up. As shown in figure 2 the area of conflict between technical customer requirements, the development within single departments and disciplines and a common synthesis, which is the main issue of an interdisciplinary integration, has to be held together by common shared data and structures.

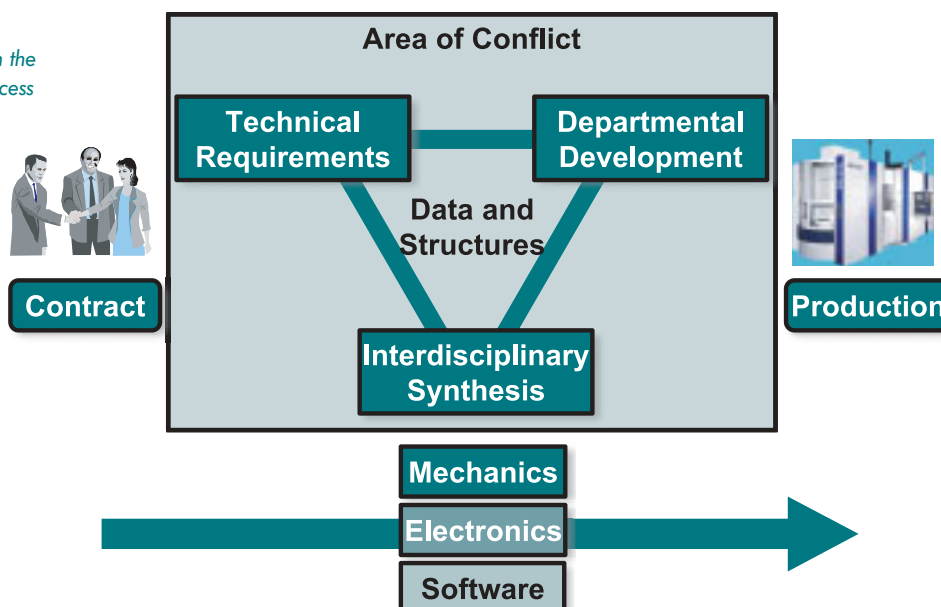
The usage of different, independent development tools in the mechatronic disciplines commonly creates difficulties, because development results in one discipline can be discussed and used continuously throughout all relevant tools in one discipline, but the exchange of data to development tools of another discipline is not always easily possible. The necessary interdisciplinary synthesis is still an extra step after the disciplinary development.

In addition, within departmental development, technical customer requirements have to be taken into consideration as a total. Since the linkage between development tools and requirement management tools is not yet consistent, only continuous data exchange and common structures can support a development focused on requirements.

An area of conflict can emerge between the interdisciplinary synthesis and the requirements, because customer demands do not necessarily focus on an integration of subsystems and technologies.

However, challenges arising from this conflict can be met by suitable management and by passing on the information that is recorded within corresponding structures.

figure 2:  
Area of conflict in the  
development process



## COLLABORATIVE PROJECT ENGINEERING TU DARMSTADT (DIK)

The global distribution of product development processes makes the use of local resources more likely. Such new possibilities lead to new business processes. Business partners not only have to deal with closer collaboration, faster flows of information and ever more complex knowledge issues but increasingly with cultural differences.

The industrial challenges as shown in figure 3 are neither new nor uncontrollable, but they are more complex, because they are networked, dynamic and on average less transparent. Although standards and guidelines for project management do exist, none so far focuses explicitly on collaborative engineering processes.

Recent industrial trends are the integration of system suppliers, portals or internet platforms for data exchange, the need for transparency of time, quality, costs and project data. A further trend is to aggregate product data in a single leading system in order to reduce redundancy or missing information. Taking these trends into account, the DiK anticipates the development of Collaborative Project Engineering as follows.

Based on an integrated computerized project, product and process model within a federative environment all relevant project data are to be integrated in a PDM system. Then a project management environment for collaborative engineering, e.g. one based on cooperation architecture for process-

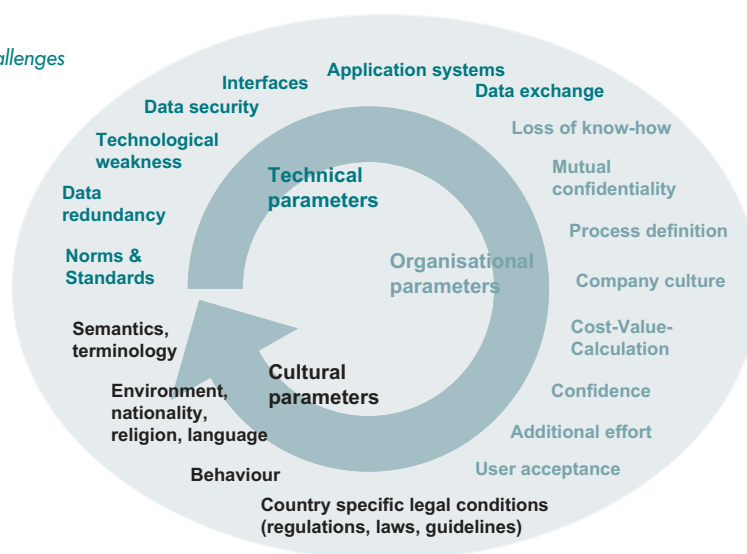
oriented applications (Kooperationsarchitektur für Prozessorientierte Anwendungen KASSA), has to be developed, providing features such as:

- a unified product data model for the data exchange between different disciplines, e. g. different CAx systems,
- methods and tools for business process management, project management, workflow management, collaborative product development and product data management, data exchange or supply chain management,
- methods and tools for monitoring the development progress, as well as the progress of cost and quality, and
- a database to store experiences.

Finally a project driven PDM will get established where the performance of a project within a PDM system will be limited to the project duration. After the expiration of the project all relevant data are written into the PDM systems of the participating development partners. In order to guarantee interoperability standards such as STEP and SADT are to be adhered to as far as possible.

The advantages of the Collaborative Project Engineering approach are the integration of different disciplines, a high transparency allowing sustainable decisions, and decreasing time-to-production due to a fast information flow and progress monitoring.

figure 3:  
Parameters of industrial challenges

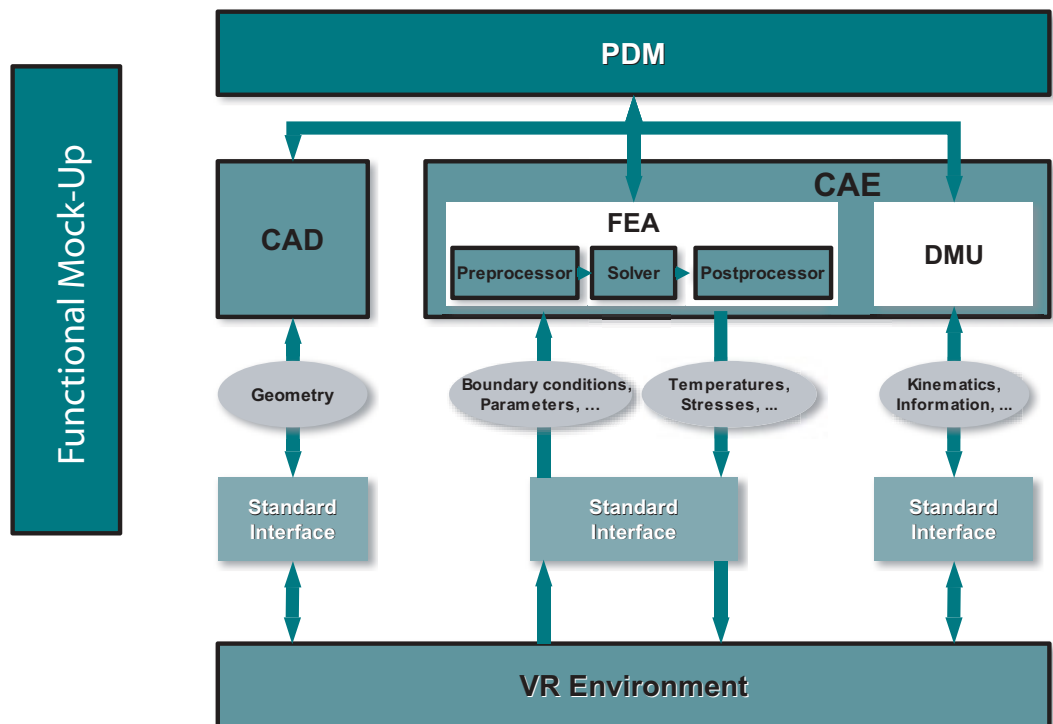


In recent years Virtual Reality has emerged from a mere visualization technique for presentation purposes to a supplement of CAD and simulation tools for product development. The use of computer aided tools such as FEA for numerical simulations plays an important role in product development because it allows to reduce development time and costs. The integration of simulation into VR environments has to be developed further in order to use the high potential of virtual technologies in the product development process. However, VR is still a one-way street. Major difficulties lie in the area of data exchange and management as there is no convenient standard available. VR is barely linked to product data management systems. A continuous VR-assisted digital product development process still cannot be supported. Common input devices used in VR environments are characterized by disadvantages such as unhandiness, high price or restricted motion. To realize a complete virtual process chain it is necessary to integrate the

whole product development process chain into the VR environment. The virtual environment can be used as a workspace with access to all applications. For representing a complete process chain using virtual reality, a comprehensive product model is required.

To solve these problems and to meet the requirements of such an approach three main areas of work can be defined. First, it is essential to develop standard interfaces to enable a sufficient and comprehensive data communication between the VR environment and engineering tools (figure 4). The second topic is concerned with the integration of engineering and in particular with simulation processes into product data management. Therefore, in both fields, the main tasks as well as appendant reference processes have to be defined as appropriate use cases. Last but not least, special human machine interfaces such as context sensitive controls should be developed to support user interaction with the VR engineering environment.

figure 4:  
Integration of the  
VR environment  
via standard interfaces



## IT-SECURITY IN VIRTUAL PRODUCT CREATION

### COMPUTER GRAPHICS CENTER (ZGDV E.V.)

Managing access to product data and digital engineering services is the major concern of IT security in the context of virtual product creation. Protection of intellectual property rights and availability of IT infrastructure are critical factors for any OEM and supplier. Today we can observe that risks and threats are steadily increasing: the strong need for collaboration, the mobility of users and upcoming technologies such as web services and GRID computing are driving forces behind this situation. To protect their knowledge and infrastructure, most of the companies have already established a high level of so-called perimeter security to control access to servers and data on the boundaries of their internal network.

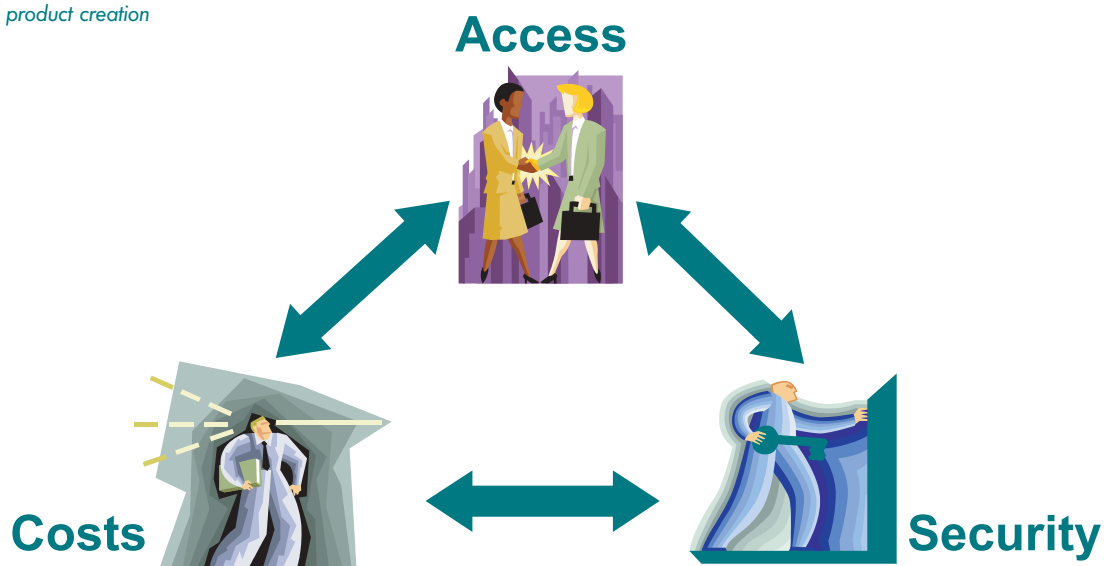
The organizational and technological developments are blurring the borders of a company and bring up the necessity for new security solutions. The current concept of perimeter security will fail in the near future. The upcoming concept of application level security shifts responsibility for encryption, authentication and access control to the applications. Here, security modules must be implemented in accordance to all specific requirements of an application domain. As a result, we will find more and more security technologies tailored for and integrated into virtual engineering applications.

Beside others, the joint study highlights the following innovative approaches that support the companies in increasing the security level in virtual product creation:

- Digital Watermarking is a well-established technology, which can be used to embed information directly in various data formats – including 3D models. This embedded information can be used to control access to the file and support track&trace applications.
- Security Awareness does not shift the responsibility for meeting the requirements of a security policy to an IT system. It rather makes risks visible for the user and advises him or her to re-think risky actions.
- Context-based presentation protects sensitive engineering information by setting sophisticated limits for visualizing, printing, measuring, mark-up, etc. Depending on the role and privileges of the user an intelligent security envelope can offer an adequate presentation of the product model.

However, increasing the security level will typically result in additional costs and/or limitations for electronic communication. To find the balance between the three important viewpoints in this context, i.e. security, access for collaboration and costs, will remain an important challenge for all the players in e-engineering (figure 5).

figure 5:  
Success criteria for IT-security  
in virtual product creation



## KNOWLEDGE BASED ENGINEERING

UNIVERSIDADE METODISTA DE PIRACICABA (UNIMEP)

Globalizing markets associated with a trend to product customization and the reduction of product lifecycle times are pressing companies ever harder to find new solutions and tools for integrating all product development phases. In this context, high quality, low costs per unit and reduced lead times are indispensable requirements to be considered during the product development cycle. Among the new technologies and tools to perform this integration in a rapid and efficient way is Knowledge-based Engineering (KBE). This technology is an engineering method merging object-oriented programming (OOP), artificial intelligence (AI) technologies and computer aided design technologies, allowing customized or automated variant design solutions. The overall objective of a KBE system is to capture the best design practices and engineering expertise into a corporate knowledge base, bringing up issues of manufacturing and assembly already at the design stage in order to accomplish a significant reduction of product development lead time (figure 6). Some high-end CAD systems widely used in the automotive and aerospace industries offer modules and/or functions for KBE

application development. They add functional features to the product model and allow analyses and verifications that have so far only been possible with physical prototypes or with additional and expensive software.

Thus, based on the modules for KBE application development available in the CATIA V5 CAD system manufactured by Dassault Systèmes, UNIMEP works on developing KBE applications with specific functions optimized for the design process that in turn prompt an intelligent and improved product development. The deployment of such applications, the study of the existent KBE systems architecture, the characterization of methods for knowledge acquisition, representation, management and distribution, will support the development of an independent system. This system should be based on a neutral format following the STEP standards. With the aid of data and information modelling languages and tools (EXPRESS, UML, XML, etc.) it is possible to create the necessary conditions for the appropriate knowledge integration with further phases of the product development cycle.

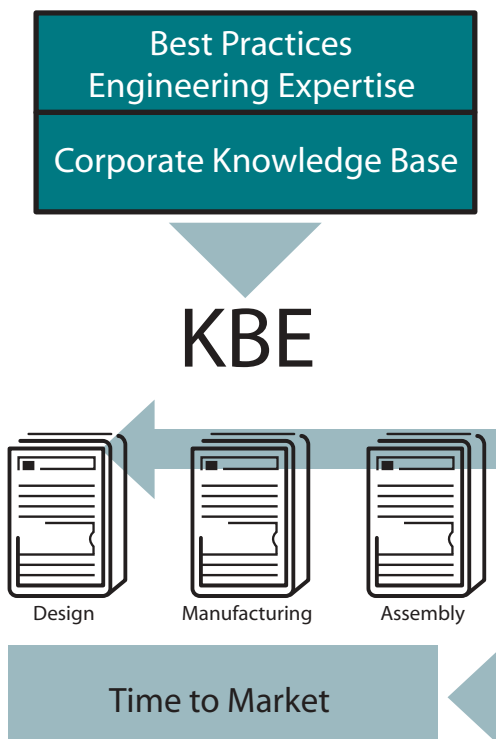


figure 6:  
KBE relation to issues  
of manufacturing and  
assembly

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