Collaborative Engineering in Product Development of Virtual Enterprises

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Abstract: - Collaborative engineering in product development is one of the most important requirements for making this Virtual Enterprise real, competitive, and widely implemented within organizations. Collaborative Engineering is a virtual methodology that tends to bring to upstream knowledge professions involved in downstream design as preparation of manufacture, production and marketing. It involves effective participation of different professions specialists in the earliest stages of conception. Mechatronic Integration technology is playing an increasingly important role in popularizing the concept of end-to-end, cross-functional design. With Mechatronic Integration modules, two engineering departments share program access and intelligence, and become more productive as a consequence.

Key-Words: - Collaborative engineering; Mechatronic Integration technology; automated software integration.

1 Introduction

This article is showing how CAD designer but also casual user of CAD systems can create in 3D in a natural and easy way, how they can share your idea on line with instant co-design, reuse those shapes in any downstream PLM applications, and modify the existing 3D shapes whatever their CAD source.

A collaborative system is defined by a large number of users or agents which are engaged in a shared activity, usually located in distant locations. As part of the distributed applications, the collaborative systems represent a separate category, because the agents within the system are working together in order to achieve a common goal and having a great need to interact each other. Table 1 shows the components of a collaborative system:

Material Component	Human Component	Energy Component	Information Component
Activity	People	Energy Resource	Procedures
Place			Flows
Material Resources			Software

Table 1. The components of a collaborative system

Collaborative engineering is defined as a methodology that allows integrated and simultaneous conception of products and production processes and associated maintenance. This ensures consideration, since the origin of all phases of product life cycle, starting with conception and ending with disposal, integrating quality problems, deadlines, demanding user costs, etc. Improved information and communication technologies (such as linked CAD tools, shared databases of engineering information, e-mail, and voice mail) can serve to break down common barriers to communication and to increase the capacity of an organization to transfer information [1], [2]. Whitney [4] points to many examples where innovative CAD tools are being successfully used to facilitate collaborative engineering in complex development projects. Though this approach may increase information transfer, it might not be sufficient for coordinating team activities since the transfer of the most essential and difficult information is not assured. The web-based Product Lifecycle Data Management System in a Virtual Enterprise is shown in the Fig. 1.

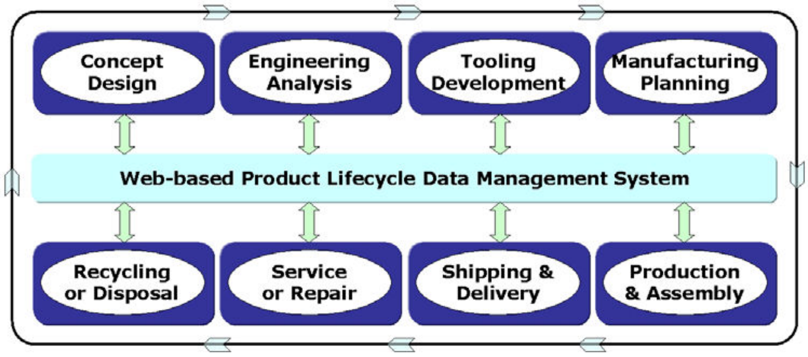

Fig.1 The web-based Product Lifecycle Data Management System in a Virtual Enterprise

2 Computer-Aided Product development in Virtual Enterprise

The virtual product comprises a digital assembly of its part models. The parts are modeled in 3D using computer-aided design (CAD) programs and saved in standard formats (ex. IGES and STEP) for exchange between different programs. Computer-aided engineering (CAE) programs enable simulating the product mechanism and optimizing the shape of each part under static/dynamic loads by simulating the internal stresses. The part models can be sent to a rapid prototyping (RP) system for automatic fabrication of a physical replica for form fit and function testing.

The tooling models (moulds, dies, jigs and fixtures) can be quickly developed by modifying the corresponding part models. Computer-aided manufacturing (CAM) programs enable planning, simulation and optimization of process parameters. Finally, computer-aided inspection systems enable automatic comparison of virtual and real parts for quality assurance.

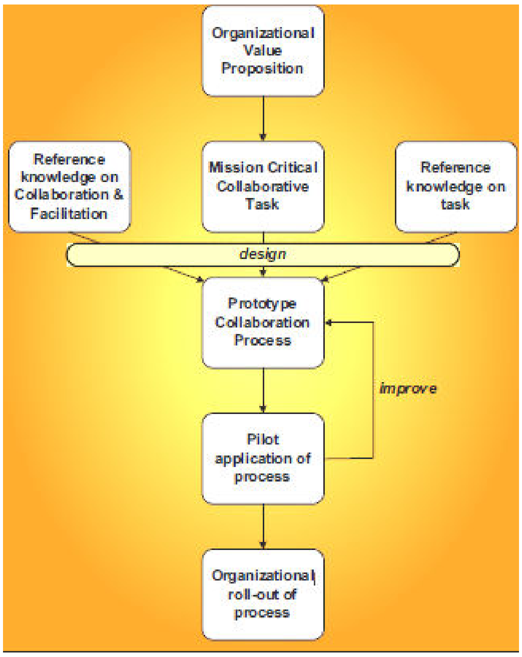

Fig.2. Overview of Virtual Enterprise Collaboration Engineering Way of Working

The 3D model is the connecting link in various CAX programs (X= design, engineering, manufacture and inspection). The programs generate a huge amount of data, which includes the solid models of different iterations and previous versions of products, as well as tooling, materials, process plans and results of analysis. This necessitates a systematic approach to data storage, verification and retrieval, which is achieved by a product data management (PDM) system.

The Collaboration Engineering way working describes the steps that need to be taken to design collaboration processes. In other words, the way of working defines the design activities in the Collaboration Engineering approach. Overview of Virtual Enterprise Collaboration Engineering Way of Working is shown in the Fig 2.

There are a number of phases that can be distinguished when we are designing a collaboration process for a mission critical collaborative task that will deliver organizational value

It is expected that these modeling tools, a.k.a. CACE (Computer Assisted Collaboration Engineering), can greatly increase design efficiency and effectiveness. Together these and other research challenges constitute an exciting agenda for the coming years. The practical value of Collaboration Engineering has been demonstrated convincingly. The Collaboration Engineering research community has only recently begun to take up the academic challenge yet the results so far are promising and stimulating.

2.1 Computer-Assisted Collaborative Systems

Computer-assisted collaborative systems present a immediate application and major advantages as follows:

1. creative activity in research, design and development of new products and applications in collaboration wit other authors areas such as: CAD / CAM (Computer Aided Design / Computer Aided Manufacturing); concurrent engineering; CASE system.
2. administrative and economic processes such as: marketing, sales, purchasing and financial (management of orders and invoices, etc.); activities; transactions processing; workflow management; staffing; office activities.

To use and develop computer-assisted collaborative systems we should consider the following key elements: group awareness; space, collections and types of shared information; methods and types of communication; knowledge of developing environmental facilities; multi-user interfaces; coordination within the group; support the heterogeneous and open environment that integrates single user applications.

2.2 Specific functional requirements for systems and collaborative engineering development platforms

To be functional in a given organizational and economic framework, systems and collaborative development platforms must meet the following general requirements:

- possibility of integration with external sources;
- the information origin for cooperating community is "groupware" external environment (examples: tools for PCs, various collections of information from relational databases, etc.);
- platform independence - "groupware" applications often begin as departments implementations, further results can be extended on a much wider area; platform independence is a basic element to ensure extensive use and investment protection;
- mobility - "groupware" infrastructure must be able to support many geographically dispersed locations, including a heterogeneous range of equipment;
- common coexistence of multiple drive applications - economic relations are linking economic partners as key actors in business processes automation, requiring the ability to easily extend the application page by successive additions.

3 Collaborative Product Development (CPD) of Virtual Enterprise

The challenge of keeping an engineering team working efficiently without getting in each other's way can be difficult to manage. Product development projects of Virtual Enterprise now involve people from multiple departments trying to collapse product introduction lead times. As if this was not complex enough, many companies are distributing these resources around the globe and forming virtual teams of people from different companies. Global design, a commonly cited alternative to the term of collaborative product design, has cost benefits that are very attractive to today's manufacturing, but adds new communication, control, and collaboration challenges and intensifies existing problem areas such as protecting intellectual property. The essence of collaborative product design in Virtual Enterprise revolves around the need to involve the entire product development team – including the company's personnel, customers and suppliers – during the development phase when a product's most distinctive characteristics are defined. More participation by team members early in the process sharply reduces the need for changes later especially during tooling and manufacturing, eliminating delays and potential cost increases. Product design and development in Virtual Enterprises are in the midst of a revolution thanks to collaboration technologies. The tools used for product design, the process of gathering input and revising designs, and the roles of those in the extended enterprise are all changing. A new generation of online collaboration tools integrated with traditional CAD is transforming the product development phase (Mathew 2002). Everyone in the product development process participates, sharing and building on one another's insights and ideas. New technologies allow people from different companies with incompatible computing systems to meet virtually on Web environments. Instead of simply sending data from PC to PC, Web tools let people talk via their computers while looking at shared documents, carry on e-mail chats, and use electronic white boards where two or more people can draw pictures or charts, in real-time, as others watch

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and respond. The benefits of such collaboration are all encompassing. Using the collaborative platform to optimize communications, schedule and to resource usage, manufacturers can significantly reduce the cycle time to bring new products to market. CPD is in demand because of its potential to cut product development cycle times. Design collaboration entails all the issues associated with discrete manufactured products, as well as those that are engineered or configured to order. These products can have a long procurement cycle, a seasonal cycle, or a short production cycle, but the key similarity is that they all start with specification documents, e.g., line drawing, schematic diagram and engineering drawing. This type of collaboration requires the specification documents to be shareable and modifiable by both parties, with appropriate audit trails, particularly with respect to the effective bill of materials and process plan referencing the documents.

In this space, computer-aided design vendors such as CATIA can leverage their design products. Traditionally, in this first phase, one party sends the document to another for review and costing via e-mail or regular mail and then collaborates on the document via telephone, e-mail, or regular mail, creating significant delays and cost overhead.

4 Product Development Teams in Virtual Enterprises

Collaborative work can be successful if all members show goodwill and responsibility. Collaboration is necessary to deal with such large projects. The collaborative and essentially social character of work needs to be appreciated in un-detracting interactive systems design. A collaborative system creates a environment where people can work better together, can share information without the constraints of time and space, being characterized by three fundamental aspects: joint activities, sharing environment and way of interaction. The solution lies in connecting the team members through a digital communications network and providing them appropriate software programs to create, analyze and modify a virtual model of the product. The model and results are stored in digital form in a central or distributed server and accessible to all team members over a local area network or Internet. This approach to product development is referred to as Collaborative Product Lifecycle Engineering. [12]

Product development teams are no longer constrained within the same four walls of the department. They are spread across different facilities, states, and increasingly across the globe. This has brought new challenges to product development, as designers must find new ways to share designs with collaborators who may never be in the same room. Companies are finding some measure of relief through a number of collaboration technologies that can help bring dispersed teams together. One solution that may often be overlooked but has a lot to bring to the collaboration table is video-conferencing [11].

5 Case study about Eplan Mechatronic Integration (EMI) applications. Software integration and collaboration between members of different departments

5.1 Integration of EPLAN and Autodesk Inventor

EPLAN Electric P8 facilitates the transparent communication of different CAE disciplines on a common platform for the first time. The system is based on a standardized database structure with an integrated graphical editor, central user rights management, and a shared viewer. From the initial design concept, through creation of a project, to generation of documentation without any additional work, EPLAN makes laborious and time-consuming drawing and cross-checking a thing of the past.

Developed from the fundamental principle of time-saving through the rapid generation of schematics and automatically generated documents, EPLAN is a PC-based software design system which can either be used alone, or by several designers working simultaneously on a project across a network. EPLAN automatically produces full, accurate cross-reference correlations, regardless of the number of drawings in the project or the number of symbols to be cross-referenced. It also manages data on connections between different wiring zones in the physical installation, automatically generating full details on connection cables and terminal wiring.

A typical 3D design and modeling system is based on a CAD engine or a data-centric architecture and provides tools for engineering, designing, viewing and manipulating process manufacturing plants and subsystems. The current project aimed at optimizing the use of E-CAD/CAE systems concerns three-dimensional planning with the incorporation of EPLAN Electric P8: in the future, will use Autodesk Inventor for three-dimensional representation of the cavern systems. Autodesk Inventor will be used for individual components rather than complete systems. There will then be three CAD/CAE systems – AutoCAD, EPLAN Electric P8 and Autodesk Inventor – which are able to communicate with one another and ultimately use the same database. In addition, projects will be clearly

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displayed in 3D. Design work proceeds more quickly, with faster project turnarounds. EPLAN Mechatronic Integration doesn't just create an IT link between two departments - it also allows both of their systems to share a common database. For example, an engineer in the electrical engineering department can work off of the same 3D model that the mechanical design team has created with Autodesk Inventor.
The designers have to work in a collaborative engineering context, having access to a common product model where they can have their own contextual views. They have to respect the just need [9] which consists of giving a constraint on the system as soon as possible if such a constraint can be proved. Integrated product design considers that the different constraints are the aim of different actors who have to control them but who "belong to the same world". [8].
The starting point for EPLAN Mechatronic Integration (EMI) is the Inventor 3D model. First of all, the designer also places electrical components such as terminals and a motor, as is shown in the Fig. 3.

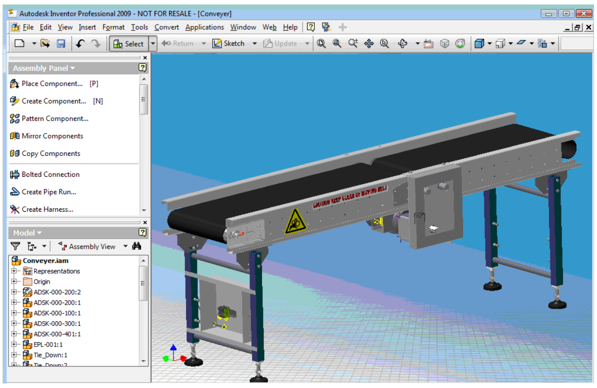

Fig.3. The designer places electrical components: terminals and motor

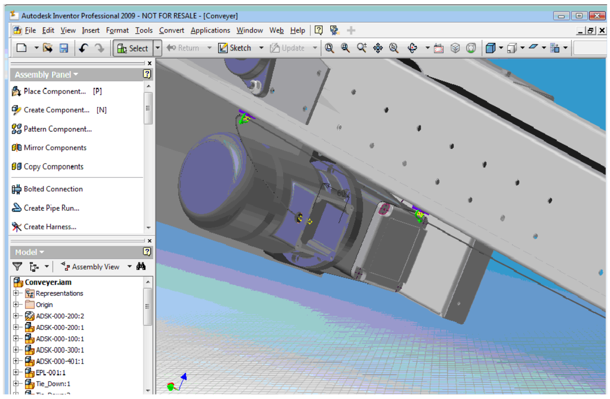

Fig. 4. The designer responsible for electrical aspects places electrical engineering components

The designer responsible for electrical aspects uses EPLAN Electric P8 to draw up the schematic corresponding to the Inventor model. The schematic correspondingly contains the components placed in Inventor, as electrical engineering components, as is shown in the Fig. 4. An important task in this stage is to establish a relationship between electrical items used in Inventor models and the corresponding components in the schematic, as is shown in the Fig. 5.

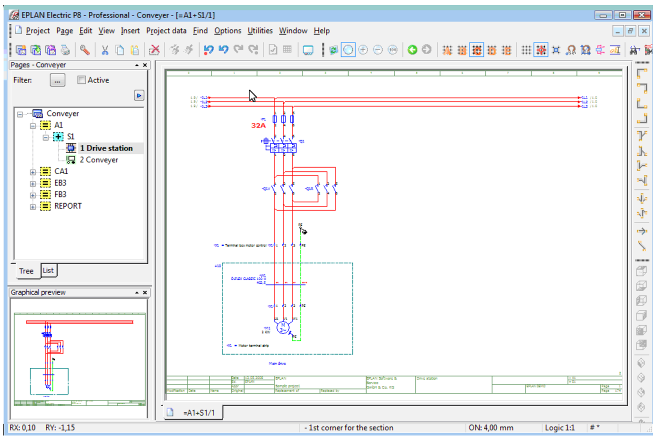

Fig.5. The relationship between electrical used in Inventor models and the corresponding components in the schematic

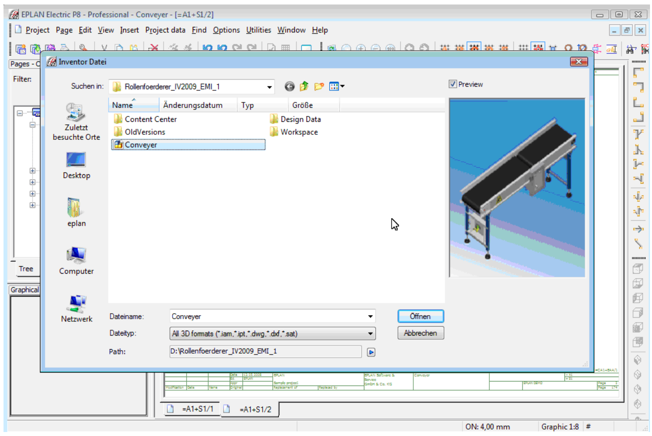

Fig. 6. The first loaded preview of Inventor models

This is the point at which EPLAN Mechatronic Integration comes into play.
To this purpose, a preview of Inventor models is first loaded, as is shown in the Fig. 6.
Another important task in this stage is for the electrical designer, who will design what he wants to add to the inventor model within EPLAN Electric P8. As a result, the complete Inventor model is displayed with this object as a 3D model to the electrical designer. He is

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now to able to see both use, a mechanical world, as shown on a left hand side and the electrical world as is shown on the right side of the screen (Fig. 7).

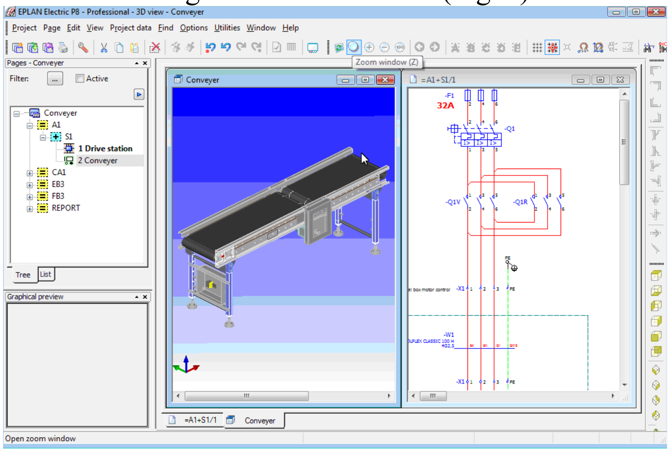

Fig.7. The representation of mechanical and electrical world on the screen

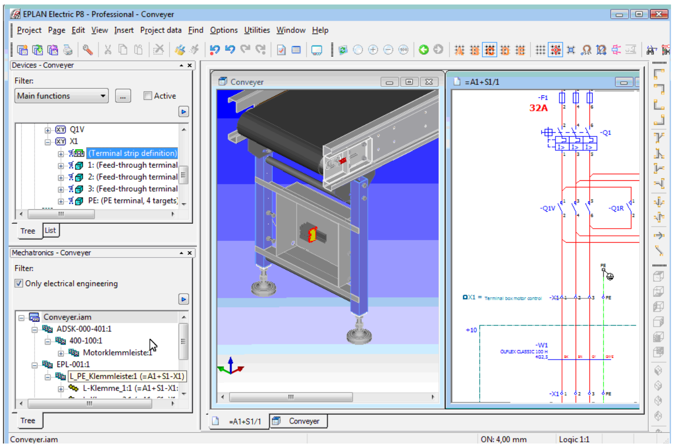

Fig. 8. The mechanical properties in the Inventor structure tree and the electrical information of the components

The workspace is EPLAN Electric P8. Now make it possible for the designer to see the electrical information of the components and the device navigator, and in the same time, the mechanical properties in the Inventor structure tree. For the improved clarity, all the purely mechanical components are already hidden in this view. There is a logical connection, both between Inventor model and the structure browser under one hand, and between the schematic and the device navigator, on the other hand. The corresponding parts can now be linked to each other by simply dragging and dropping them (Fig. 8).

From this point on, EPLAN Electric P8 knows where the corresponding mechanical representation can be found in the Inventor model. Since the geometric constraints are now also known in EPLAN Electric P8, it is possible, for example (Fig. 9), for the length of the cable between the terminals and the terminal box and the motor connecting terminals to be calculated.

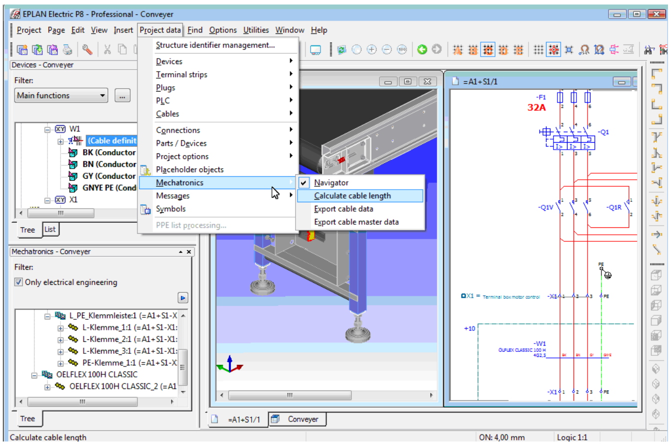

Fig.9. The corresponding mechanical representation from the Inventor model

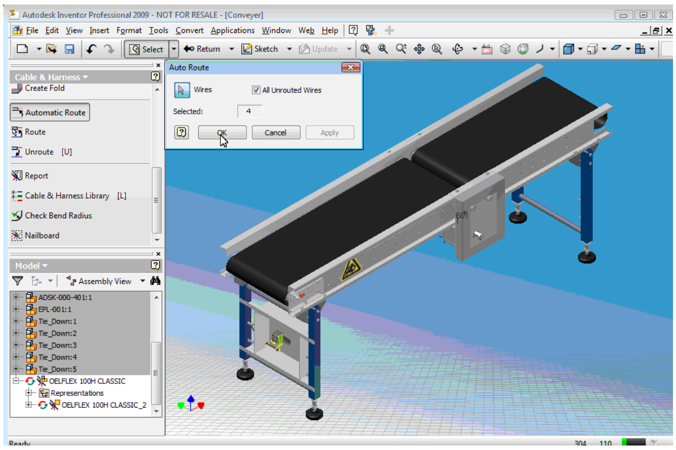

Fig 10. The cable runs along the predefined lane route

It is for the more possible to make the connections information available to the cable module of Inventor Professional in the former connecting point identifiers. This is already into Inventor and, as we know shown you on the display as cables assembly data. This data can now be used to carry out automatic connection of the wise along the cable lane groups, planned by the mechanical designer.

The individual wise of the cable are connected correctly to the terminals in according with this connection information. For example, the green yellow conductor is connected to the grounding terminal. The cable runs along the predefined lane route (Fig. 10).

The designer is now able to check the actual cause of the cable and the individually connected conductors. If the mechanical designer changes the design details after words in the Inventor model, for example by changing

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the cable lane routes, the resulting cable length is, in turn, made available to the electrical designer in EPLAN Electric P8. With this example, EPLAN Mechatronic Integration illustrates impressively ours smooth and continuous exchange of information between two CAD, CAE applications; EPLAN Electric P8 and Inventor professional can function. The designer in the different departments mutually profit from their respective work resulting in a reduction in time and the errors been minimized.

6 Conclusion

Collaborative Engineering is a design approach for recurring collaboration processes that can be transferred to groups that can be self sustaining in these processes using collaboration techniques & technology. The above sections have presented the different 'ways' of the Collaboration Engineering approach. The collaborative conception or co-design of products and associated processes takes place in space, through meetings of experts of different professions and in time, by organizing parallel activities. In this way now arises the new products development issue. The integrated approach is ensuring short terms for products conception and launch, increasing quality and reducing production costs. The relevant and easily accessible obtained information is a key element in the operation of modern companies. In the company systemic approach, information system is linking the components of management and other systems at the micro level.

The Autodesk Inventor product line provides a comprehensive and flexible set of software for 3D mechanical design, simulation, tooling creation, and design communication that help you cost-effectively take advantage of a Digital Prototyping workflow to design and build better products in less time. The Inventor model is an accurate 3D digital prototype that enables the users to validate the form, fit, and function of a design as they work, minimizing the need to test the design with physical prototypes. By enabling the users to use a digital prototype to design, visualize, and simulate their products digitally, Inventor software helps them communicate effectively, reduce errors, and deliver more innovative product designs faster.

Inventor is tightly integrated with Autodesk data management applications, enabling the efficient and secure exchange of design data and promoting earlier collaboration between design and manufacturing workgroups. The common goal of integrated product design is to reduce the cost, to reduce the time to market, to take into account sustainability and to increase product quality.

Time-saving, improved quality and efficiency are all key benefits available to the designer using EMi's engineering design tools. The engineer can reduce the design process by as much as 90% while improving the quality of the project documentation by eliminating unnecessary errors.

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