Increased efficiency in Plant Engineering

SIEMENS

White Paper

The more complex the plants, the more global the project management, the greater pressure on time and costs, then the more important smooth and optimized processes in the field of plant engineering become. This can be ensured by data management that is as consistent as possible and which accompanies the whole process from the initial planning steps to process control project scheduling.

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The pressure of international competition is also making itself felt in the field of plant engineering – for example, development times need to be shortened and project costs reduced. A consistent, efficient plant design is therefore more in demand than ever before, as it saves both time and money.
But the work-flow in the engineering of process plants is and remains a challenge: the high number of persons involved, a plethora of different data formats and interfaces often result in transmission errors and system discontinuities and this leads to a greater expenditure of time and money. Integrated and consistent planning data are therefore decisive factors for competitive success. The introduction of modern 3D-CAD-programmes has created an important basis for this. The deployment of standardised interfaces and central data management already make a continuous work progress for the individual stages of procedural planning possible today. The smooth merging of process planning and control technological engineering through integrated planning is the next step towards increased efficiency.

Contents

Motivation

Before a process plant can be taken into operation, a variety of individual, independent planning stages is necessary, in which the most varied of specialist disciplines (so-called trades) are involved. These range from process technology through mechanical engineering and EMSR-technology to software-programming. The specific know-how of all those involved must be integrated into the overall project. Each of the disciplines has recourse to specific methods and tools; the element combining them is the utilisation of computer applications to support the planning. This Computer Aided Engineering (CAE) is an important component in the handling of the respective tasks. The spectrum of software deployed in this ranges from self-programmed developments of one's own and established applications that are used at specific stages of the development, through to trade-spanning tools that have come to define quasi-international standards. The process of engineering is strongly dependent upon the division of labour, i.e. the planning of automated industrial plants is a very complicated structure that those handling the individual stages can only survey in its entirety with difficulty, if at all. Mutual dependencies are indeed known, but are often not seen as a problem. Those involved process the planning data in the format necessary for their own work and then pass them on. Data consistency is at its most important at the time of transmission. This leads to a multitude of discontinuities in the entire process, data must be transmitted in the form appropriate to the respective tools. With regard to the three important key factors in today's engineering projects, quality, costs and adherence to delivery dates[1], it is imperative that multiply data entries, different levels of information and lack of transparency in the documentation should be avoided. This fact has been known for years, and a number of endeavours are being undertaken to ensure a smoother exchange of data between the individual trades. Because a consistent system of data management increases the flexibility within the overall process, enabling the parallelisation of tasks and contributes to cost reduction.

This white paper will demonstrate which approaches have been developed during the past years regarding the planning and realisation of plants, in particular pertaining to control technological project management, the potential for rationalisation from which plant operators can already profit today and the future developments that are conceivable.

[1] cf. Thomas Tauchnitz: *CIPE oder: Die Zeit ist reif für eine Integration des Prozessentwurfs-, Engineering- und Betreuungs-Prozesses. Teil 1.* CIPE or: The Time is ripe for an Integration of the Process Design-, Engineering and Supervisory Processes. Part 1.
Part 1. In: atp – Automated technical practice 47 (2005), Issue 10, S. 36-43.

Committees and Norms

An increase in engineering efficiency may be achieved in various ways. For example, software manufacturers attempt to guarantee them by expanding functionalities or by creating inter-disciplinary tools. Standardised interfaces that allow exchange to take place between the various trades also afford the possibility of minimising the transaction expenditure along the value-creating change. A number of international organisations concern themselves with the improvement potential that is latent in engineering and give, in part, concrete recommendations for actions to both software manufacturers and users. In the following, a selection of basic guidelines and recommendations are presented in short from. The work of the committees named and the results they have achieved form the basis of a methodology by means of which the interface problems could be solved. Besides those cited here, efforts are also being made at international level with the same goal in mind.

GMA 6.12

Integrated Engineering of Control Systems

The GMA expert committee "Integrated Engineering of Control Systems" of the VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik (Association of Measuring and Automation Technology) was founded in July 2001. This body is made up of ca. 20 experts from industry, universities and research institutes. It first of all reviewed the effects of the transformation in the world of information technology on the engineering workflow. In close cooperation with the NAMUR-working group 1.3 “CAE-tools”, the committee identified, from the point of view of an inter-trade usage of software applications, important engineering subtasks, and subsequently drew up a model for a corresponding engineering workflow. Particular attention was paid to particular key points, for example, the transmission of process engineering and mechanical planning information to the DCS planning.
An “Engineering maturity model” has been worked on since 2007 that will enable companies to undertake a clear assessment of their own engineering activities with regard to the various prerequisites for an efficient system of engineering. The determination of the “degree of engineering maturity” helps exploit improvement potential in a purposeful manner and to make the right investments.

VDI/VDE 3695

Plant Engineering – Evaluation and Optimisation of engineering

The series of recommendations VDI/VDE 3695 books 1 to 4 (published in May 2009) is a significant publication by the above-mentioned GMA committee. They deal with the procedure for evaluation and optimisation of the engineering of plants and are intended as an aid to engineering companies. The series refers to the technical, organisational and economic environment of engineering projects. On the basis of the classification within a catalogue of criteria, measures for the carefully-aimed further development of the engineering organisation can be identified and selected.
The guidelines serve companies as a support in the estimation of the status of their own organisation. Beyond this they also reveal which target statuses may be worth striving for under the given framework conditions and they also indicate possible paths leading thereto. The costs, risks and opportunities associated with the introduction of a particular action are also dealt with.

DIN EN 62424

Description of tasks in the field of process control technology – flow charts and data exchange between EDP-tools for the creation of flow charts and CAE-systems

The responsible national working committee DKE/K (German Committee for Electrical Engineering) 941 “Engineering” concerns itself with the uniform description of the demands made upon process control technology and data exchange between P&ID-and PCT-tools. In addition to the graphical depiction of the PCT-requirements in the P&ID flowchart, this norm also presents the neutral data model CAEX (Computer Aided Engineering Exchange), with which the data interface between tools for the P&ID-procession and the PCT-planning can be realised independent of the manufacturers. CAEX is based on the Extensible Mark-up Language (XML) and is a neutral data format for the storing of hierarchical object information. The data format was devalued by the RWTH Aachen in cooperation with manufacturers of control technology planning tools and plant operators. After a positive international voting, CAEX was published in May 2005 as a part of the IEC PAS 62424. With the 2008 publication of the IEC 62424 {Ed.1.0} CAEX is in the meantime available in version 2.

NE 100

Utilisation of lists of properties in the PCT-Engineering workflow

The basis for a uniform flow of information in the engineering phase is the use of a common language. The NAMUR-recommendation NE 100 creates this basis with its standardised properties: it provides a method by means of which both PCT-devices and systems as well as their deployment environment and requirements (e.g. design data), are described in a standardised manner. Each type of device is defined by a list of properties in which the relevant properties are arranged. The PROLIST-device specifications provided by the NE 100 are classification-neutral properties and thus applicable to other classification keys such as eCl@ss, UNSPSC etc. What is required are properties and lists of properties both from suppliers and manufacturers and also from users and customers in order to be able to plan, design, service and procure process controlling devices and systems. The usage of the NE 100 makes it possible to optimise, on the one hand, the processes between the partners and on the other internal company processes (e.g. engineering, development and procurement).

Basic Principles

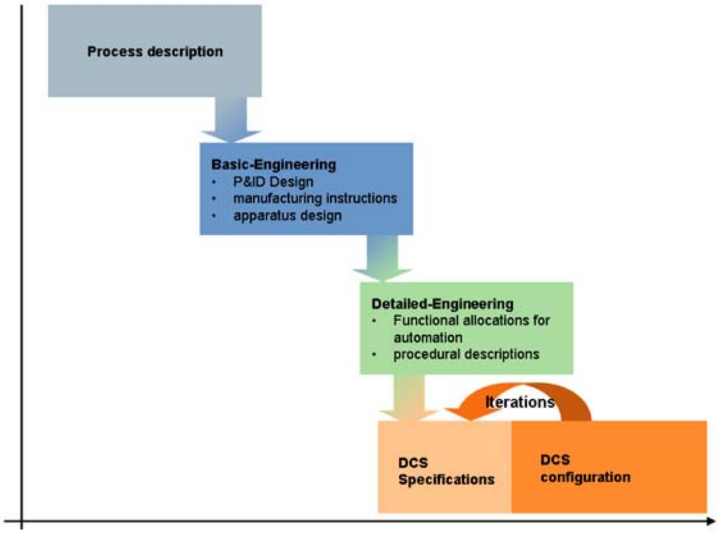
Computer Aided Engineering (CAE)

By engineering one understands "The planning and realisation of automated industrial plants as a whole of the automated-technical equipping of plants".[2] The most important of the trades involved in this process – process planning, plant planning and process control planning – all have recourse to CAE-software. On the basis of the computer-supported engineering, all trades attempt during the planning phase, to portray the correct construction of the plant with the aid of models long before they are actually constructed. In their root form, the computer-supported design, the CAE-programmes were not particularly helpful at first with respect to process-oriented problem-solving. They rather served the purpose of portraying a solution that had already been worked out. Software manufacturers have succeeded in rectifying this defect to an increasing extent during the past years. Along with the development of the programmes, the task-based support for the work to be done was guaranteed to an ever increasing extent. In the engineering field, tools provide assistance with regard to the organisation, project management and purchasing departments. They help with the compiling of concepts, functional planning, analysis or optimisation. They also serve the purposes of administration and enrichment of plant-related data.
The pieces of information received from the various trades do not exist independently of one another, however. The redundant storage of data in individual tools has been recognised as a problem. In order to optimise this, Tauchnitz had already proposed the following basic principles in 2005:

- Each piece of information should only be entered and updated at one particular point.
- Available knowledge should be reused as far as possible.
- All tools remain linked to one another as long as the plant is operated and changed[3]

Process flow

The description of the process is the beginning of the plant planning. The engineering systems of the individual trades are supplied with basic information on the basis of these verbal descriptions. Procedural and pipeline technicians as well as automation specialists begin their work on the basis of this information: P&ID-schemata come into being. Manufacturing instructions, apparatus designs, quantity and volume flows etc. are established. At all later stages of process, the apparatuses will be allocated and requirements defined. Subsequently, the appropriate functional components will be selected for the automation system. On the basis of the description of the procedural flow, the automation engineer is able to compile functional plans for Continuous Function Charts (CFCs) or Sequential Function Charts (SCFs). All information and specifications are used in PCT-engineering, PCT-locations interconnected and parameters defined for them. The software engineer incorporates this information, e.g. I&C points, I/O-assignments or basic regulatory circles, in the configuration and takes care of the creation of the software in the automation process. At a number of the stages questions arise: the entire process is iterative and passes through several cycles.



Process flow and interfaces

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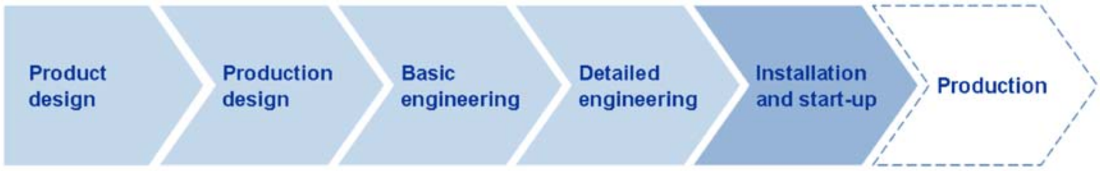
2 Alexander Fay u. a.: How can the Engineering Process be systematically improved? In: atp – Automated Technical practice 1-2.2009, pp. 80-85, here S. 80.
3 Tauchnitz: CIPE, S. 38.

Life cycle

The general planning process described is a very important phase in the life cycle of a plant. During this phase the technical, organisational and economic fundament for the plant are developed. The subsequent phases are based upon the results achieved here; modern maintenance systems use data from the project phase.

As overview of the life cycle model with a low degree of detail.

A rather more detailed view of the abstracted life cycle of process engineering plants provides better orientation within the planning and installation phase:



If one wishes to base one's view of the workflow upon a more exact procedural flow, then one runs up against limits: the demands in the field of plant engineering are too different (e.g. the difference between Turnkey- and First-of-its-kind-plants), companies follow their respective individual workflows etc. With the aid of the model of the life cycle, however, more or less sequential procedural steps and corresponding transition points can be identified. In the following the planning phase as an example for a multi-disciplinary way of working and the transition from the planning phase to the start of operations are regarded more closely.

The Planning Phase

The subdivisions within the planning phase of the life-cycle model reflect the fact that a number of trades are involved in the total planning process. The plant planners for the Front End Engineering and Design (FEED) often work for completely different companies than those who are responsible for the Detail Engineering or the purchasing and construction planning etc. The tasks to be carried out in the individual phases of the project require the expert knowledge of specialists.

Front End Engineering and Design (FEED)

Here, a rough planning is undertaken which is decisive for the following tasks. The production process is drafted and simulated. Process specifications and procedural flowcharts are compiled in order to describe the plant.

Basic Engineering

The results of the FEED are refined, the tender for the plant drafted and documents for the approval process compiled. Planning engineers decide upon the deployment of apparatuses, machine and pre-fabricated components, so-called "Package Units". Specialist engineers and process technicians develop the flowcharts for the pipe lines and instrumentation, so-called P&ID – Piping and Instrumentation Diagram). These form the schematic basis for the plant: apparatuses, engines, pumps etc. are depicted symbolically and joined together. Measuring points are indicated for the measurement and regulatory technology. Thus the foundation for the control technology concept and the measuring principles are developed. Furthermore, consumers of electricity are identified and circuit diagrams conceived.

Detailed Engineering

Before the plant can be built, an exact specification is required. This is the phase during which the apparatuses, machines and other pieces of equipment are ordered. A 2D- or 3D-installation diagram makes the locations of these parts of the plant visible in a 'virtual environment'. In the Detail Engineering phase, the functional plans, the field planning and the documentation of low-to-medium voltage applications and the automation (on the basis of comprehensive plans such as circuit, cable and cabinet arrangement plans etc.) are compiled. In this phase, the plant planning (up to this point neutral with regard to the target system) is bound to a particular system, i.e. now at the last, the decision is taken in favour of a specific DCS. In this regard, the libraries for the types of measuring points and hardware are designed in accordance with the specifications for automation during the detailed planning stage.

The Path to more Efficiency

This brief outline makes clear the number of inter-disciplinary tasks that require the deployment of the widest variety of tools. The consistency of the tool chain is decisive for an efficient engineering workflow. The VDI/VDE-guideline 3695 "Evaluation and optimisation of plant engineering" demonstrates this in detail and vividly. The category "auxiliary materials" of this guideline is decisive for the following reflections. According to this category, the consistency of the tool chain may be achieved via four attainable target statuses. Reflected in the software developments of major manufacturers this results in the following picture:

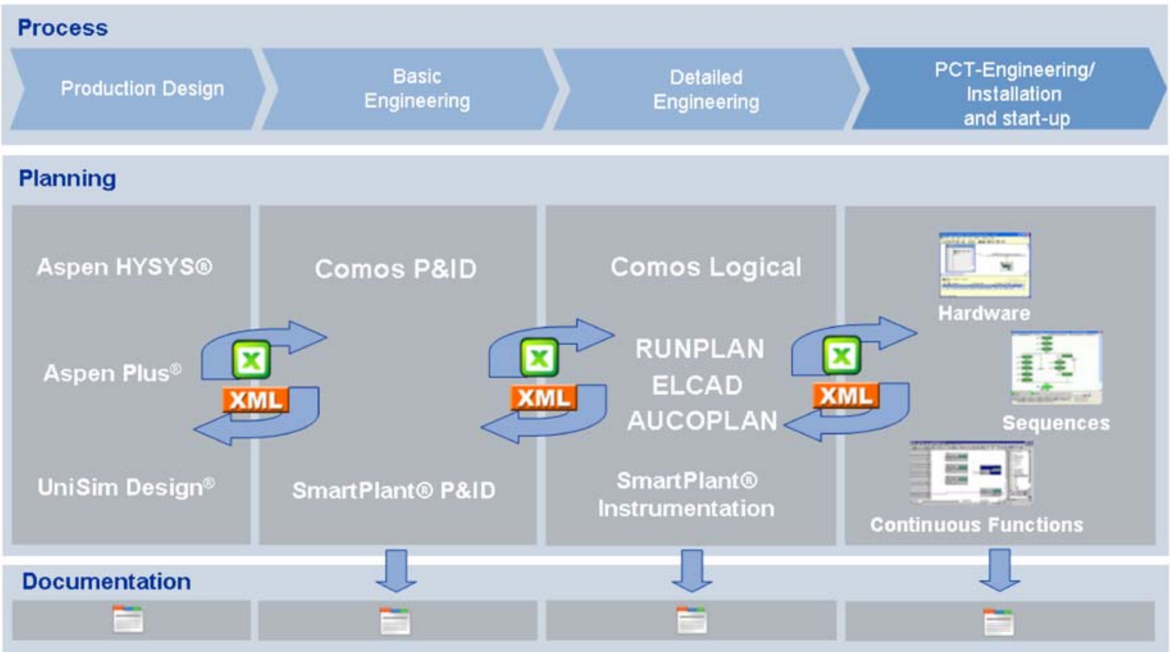
- **Target status A:**
  Electronic documentation of the planning
- **Target status B:**
  Deployment of computer-supported planning software with data formats that can be evaluated on computers → heterogeneous planning
- **Target status C:**
  Data exchange between tools via corresponding interfaces → homogenous planning
- **Target status D**:
  Automatic electronic data exchange within integrated systems → integrated planning

Target status A has today already been realised in the majority of cases, in particular with regard to larger-scale plans: the documentation is prepared in electronic form and no longer only on paper. The special characteristics of Target statuses B to D will be discussed in more detail below.

Heterogeneous Planning

A plethora of participants, a plethora of tools and therefore also a plethora of data formats – is often the reality of planning projects. Even admitting that a comprehensive list of the tools deployed, naming their areas of deployment and data formats, cannot possibly be reproduced here, the nature of the problem may be illustrated using an example scenario:
Whilst MicroStation from Bentley is being used for the 3D-planning, Intergraph SmartPlant P&ID is deployed for the generation of database-supported P&ID-schematic drawings, ELCAD from Aucotec for the electro-technical equipment planning and Comos as the central document management system. The trade responsible for the switch cabinet construction uses ePLAN cabinet for the configuration of the mounting plates and the wires. The companies commissioned with the laying of the cable routes can carry out their tasks using the data processed in ePLAN cabinet.

Not only do the individual trades from the planning stage have recourse to the P&ID flowcharts, but these may also be further edited and documented using the Intergraph application during the operational phase. Suppliers of control systems can pick out information pertaining to the DCS-configuration via interfaces.
The heterogeneous form of plant planning can be equated to the target status B defined in VDI/VDE 3695: the planning data from the various tools are available in the form of data that may be evaluated by computers, either in a proprietary file format or e. g. as XML- or CSV-files. These files are on principle reusable and valid for various trades. However, as a rule, information is either lost during the exchange between two kinds of tools or it has to be improved manually afterwards.

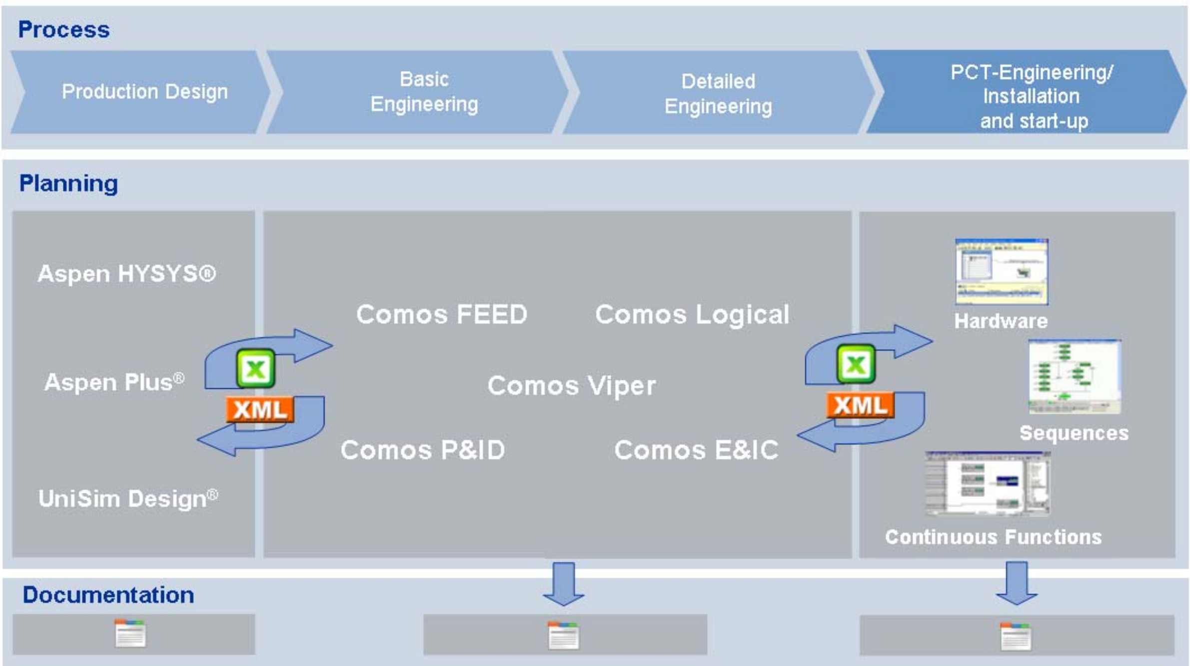


Homogeneous Planning

More and more tool manufacturers are offering a comprehensive portfolio and supplying the trades with task-oriented tools from a single source. Proprietary interfaces often ensure the exchange of data; the use of standardised interfaces would be preferable. The import or export is initiated manually by the user. Thus target status C is attained: electronic data exchange between tools in accordance with the work procedures. This exchange can also function between software applications made by different manufacturers, assuming there is a standardisation of interchange format and interfaces.
Three things are decisive for the exchange of data: syntax, semantics and overlapping of the data. The IEC-Norm 62424 offers decisive answers with regard to syntax. It places the P&ID flow scheme at the centre of the plant planning, as it is in this central document that the information from procedural and piping technology are consolidated and it therefore represents an important data basis for the automation technology. At the same time the norm also introduces the neutral, XML-based data model CAEX, which enables the exchange of data between tools, independent of manufacturer and trade.
The principle is based on the storage of hierarchical object information with which the plant structures may be illustrated.

CAEX makes the storage of abstracted modules of this hierarchical plant structure, by means of a strictly object-oriented approach, in which concepts such as classes, class libraries and institutions, inheritances and attributes take effect. CAEX is thereby not a rigid data model: objects and their relationships are not pre-defined but can be freely added and altered. With the aid of CAEX, data can be automatically exchanged between tools without a human plausibility check.
Whilst this norm regulates the syntax, i.e. the formal ordering of the data, the NAMUR-recommendation NE100 can be regarded as the semantic or meaningful component for the data exchange. The NAMUR project group “Properties Lists” (Prolist) defines and maintains properties and property for devices and systems from the field of EMSR-technology. By using pre-defined concepts (properties) products and services can be described independent of manufacturers. This enables devices to be searched for independent of the suppliers, on the basis of certain properties which have been identified during the planning phases as critical for the realisation of a plant. These standardised properties allow the exchange of data between arbitrary computing systems.

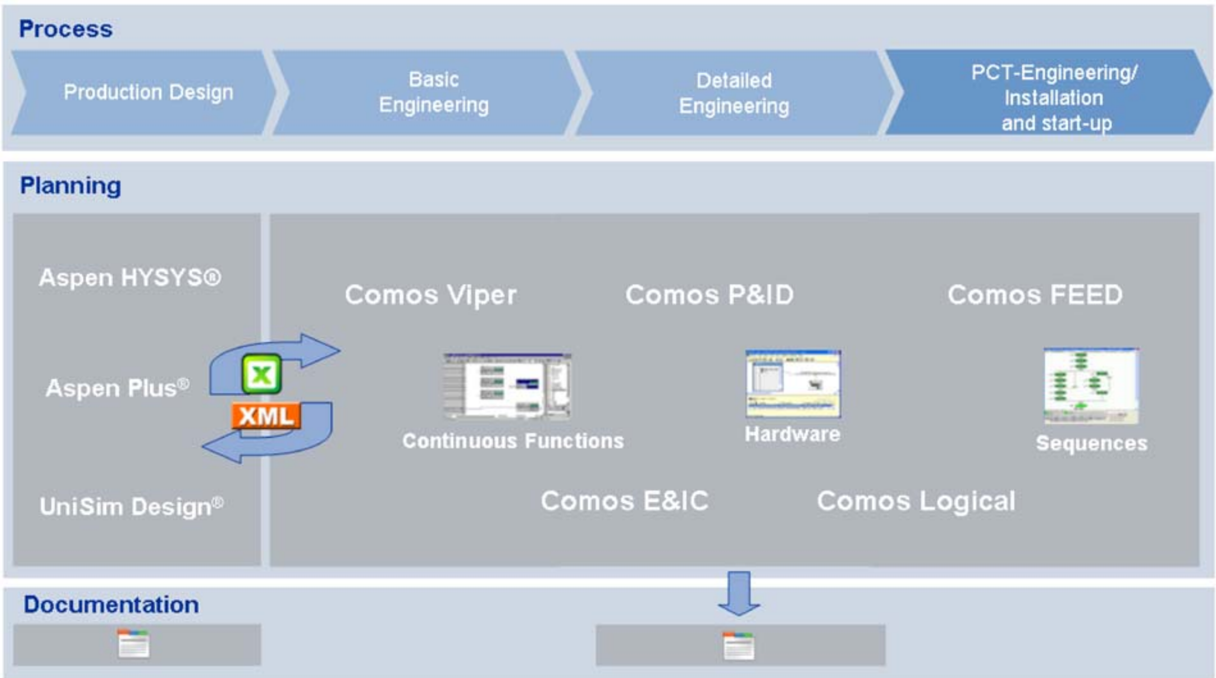
Homogeneous Planning with Comos PT



Integrated Planning

The target status D quoted in VDI/VDE 3695, which describes an automatic electronic data exchange with independent consistency review, and data-linkage can only take place in completely integrated tool packages. The strict honouring of this status would mean data consistency throughout all trades including DCS-engineering and has to this day not yet been attained. Only the deployment of one single data basis would enable this exchange of data without any transformations. A centralised or completely consistent storage of data in appropriate databases is absolutely essential for this.
So far this approach has only been pursued by a limited number of companies in the field of process technology planning: Intergraph offers its “The Engineering Framework”, ePLAN the “Engineering Center” and Comos “Comos PT”. These software suites provide application modules for specialist applications on a single platform. The exchange between the applications is done completely automatically. In the course of the planning objects are furbished with an increasing volume of information that is added to be the individual trades. In their turn the trades have at their disposal a specific view of the object – information irrelevant to their own tasks are shut out.
These objects can be provided with substructures and relationships so that, from the individual elements, a model of the plant may be developed. The graphic and alphanumerical characteristics of an object form a common unit within the database. A smooth merging of procedural technological planning and control technology project work can only succeed on the basis of rigorous cooperation between the providers of planning tools and manufacturers of process control technologies. Since 2009, in the shape of the Comos Industry Solutions GmbH and the Siemens AG, two companies which are global leaders in their fields, are working together on the realisation of this vision.

Integrated Engineering using the example of Comos and Simatic PCS 7



The Operational Phase

The handing over of the plant to its operator marks the end of the planning and construction phase. In the context of the start-up, PCT-Data, in particular, are frequently subjected to changes. Plant-wide access to up-to-date project data and an intelligent system of revision management are the keys to a smooth start-up of operations. To this end, a smooth exchange of data between planning tools and DCS-engineering is required: consistent documentation can only be provided if the systems, at the time of change, are on the same level of information. This is very important in plants for which qualifications are mandatory, for example pharmaceutical industry plants, whose revision methods are compatible with GMP.

Upon the transmission to the operational phase the tools also change: operations-accompanying systems for repair and maintenance work or Enterprise Resource Planning (ERP) systems are crucial for this stage of the plant's life cycle. These systems also require information that has already been collected during the planning phase: maintenance requirements, inspection plans, device characteristics, etc. These should be taken over directly from the CAE-tools.

A further important component of efficient engineering is the planning and documentation during on-going operations. During the life time of a plant, alterations, expansions and optimisations are everyday occurrences. These alternations are made under enormous time pressures and for this reason alone, in many cases it is necessary to waive the advance procedural documentation. This changes the workflow and one must be in a position to restore the alternations carried out on the plant during operations in the planning "as-built" – another argument that speaks for homogeneous and/or integrated planning. This way of proceeding constantly keeps the documentation up-to-date and ensures data consistency from the request via the draft version through to realisation. On the basis of up-to-date planning data, planned expansions can already be reviewed for their feasibility in the run-up, e.g. with regard to the available space, capacities etc. Thanks to the standardisation of interfaces and/or integrated data storage on a life-cycle-oriented platform, information remains intact throughout the operational phase. Data formats independent of manufacturers thereby lead to a greater degree of independence of the plant operators in the choice of their providers. Even changes to the controlling system can be realised with far less expenditure on the basis of up-to-date and complete planning data.

Summary

The optimisation potential in plant planning is far from exhaustive. Nothing much is likely to change regarding the multi-disciplinary nature of engineering, but for the tools it is a very different story: in order to be able to shorten project times, offer task-specific support and guarantee consistent documentation, the planning tools of the future need to be optimised even further. The committees and norms mentioned show the way forward in this respect. Integrative approaches using planning suites on consistent data platforms will become still more effective when DCS-manufacturers are able to place their tools directly upon it. The approach of a closer cooperation between planning software suppliers and control technology manufacturers will make a decisive contribution in the future to the development towards an integrated plan across trade boundaries. In this way customers have numerous possibilities available for increasing the efficiency of their work, shortening planning times and reducing costs.

For the immediate future, enormous potential is being subscribed to the so-called "Virtual Engineering", in which all planning is done in 3D. In virtual rooms production processes will be run through, entire plants devised, unresolved questions between the various trades explained with the aid of the virtual object and pros and cons weighed up - live using the models.

A high degree of flexibility will continue to be decisive for further increases in efficiency in the future. Tools will have to permit and support a wide variety of totally different planning processes and industry- or company-specific planning methods. Even the best tool that enables consistent planning does not, in the final analysis, bring any added value if it does not grant its users a sufficient degree of freedom.

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