# Mechatronic Development – an Interdisciplinary Challenge

**Mechatronic Product Architecture**
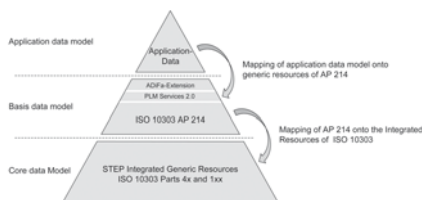
**Digital Factory**

**ProSTEP iViP Symposium 2009**

# Content

## Mechatronic Product Architecture

Today, manufacturers of sophisticated technical products and their suppliers face immense challenges driven by the increasing complexity of products, processes, and technology, and ever shorter time-to-market cycles. Many current development projects miss the targets set for deadlines, quality and costs, sometimes by wide margins. In addition to technical and technological know-how, interdisciplinary work methods and target-oriented development management are increasingly becoming key skills. *40ff.*

## Digital Factory

Planning tools are not yet as well integrated in the digital factory as they are, for example, in the design field. The main reason for this is that there are as yet no standards for the description of production planning data. In order to enhance the integrability of the digital planning tools available for production planning, the ADiFa joint project is developing a methodology intended to standardize the exchange of the planning data required for the digital factory. *45ff.*

* The focus lies on mechatronic

# 10 Years of Interoperability: The CAx Implementor Forum

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**In May 1999, the ProSTEP iViP Association in Germany and PDES, Inc. in the United States combined their efforts to support the development of STEP processors for CAD systems and the relevant parts of the STEP standard, and merged their until then separate activities into the CAx Implementor Forum. This project group can now look back on ten years of trustful and successful work.**

Before the CAx Implementor Forum (CAx-IF) was established, the development of the STEP standard and guidelines for its use was facilitated separately on both sides of the Atlantic and reach back as far as 1994.

## STEPnet and RoundTable

PDES, Inc. is an international industry/government consortium committed to accelerating the development and implementation of standards that enable enterprise integration and Product Lifecycle Management (PLM) interoperability for its member companies, which represent leading manufacturers, national governmental agencies, software vendors and research organizations. Testing of implementations and data exchange using the ISO 10303 standard, in the scope of the CAx-IF predominantly AP203, is an integral part of PDES, Inc.

After the first commercial STEP processors for AP203 became available in late 1994, PDES, Inc. organized a week-long so-called "plugfest" in Charleston, where the developers had the chance to test their implementations an ensure interoperability between them. The participants immediately recognized the value in such an exchange of experience, so the activities were carried on over the internet and subsequently became known as the STEPnet forum. PDES, Inc. recently celebrated its 20th anniversary of being in existence. The CAx-IF was noted as being one of the organization's highlights.

The ProSTEP iViP Association, which was founded in 1993 to secure and carry on the results of the ProSTEP research project, also started its RoundTable activities with a number of CAD vendors in 1994, focused around the development of AP214. Here, too, the initial testing evolved into an ongoing distributed forum to support both the STEP processor developers as well as the standardization groups. With its about 200 members, the ProSTEP iViP Association was able to provide requirements and quality criteria to the test forum, and in return prove the stability of the created processors in the Benchmarks, eight of which were conducted between 1996 and 2003.

However, there was a significant overlap of the two activities, STEPnet and RoundTable, both concerning the testing scope and the participants, resulting in a number of difficulties. The administrative efforts to facilitate the two separate activities, the resulting high technical workload for the participants, and last but not least emerging conflicts in implementation guidelines finally lead to the decision to merge the two groups into one combined testing forum.

## The CAx Implementor Forum

Ten years ago, in May 1999, the CAx Implementor Forum was formed as a joint venture between PDES, Inc. and the ProSTEP iViP Association. The first workshop of this joint group was held in Darmstadt. The organizational efforts are split between the two organizations, with the review meetings concluding each test round taking place alternately in Germany and the United States.

As the preceding activities, the CAx-IF is a closed group, i.e. no detailed test results will be published. All participants have to sign a non-disclosure agreement, and the test models are

treated confidentially. This approach has created a remarkable atmosphere of trust over the years, and is one of the foundations of the CAx-IF's success.

The public results the group creates include the so-called Recommended Practices – guidelines how to implement specific functionalities in STEP in a harmonized way, thus ensuring inter-operability, summaries of the testing activities and sample STEP files to aid other implementors. Furthermore, the forum closely works together with the different standardization teams to guarantee both AP203 and AP214, as well as the underlying resource parts in the STEP standard support the user require-ments as provided by both PDES, Inc.'s and ProSTEP iViP's member companies.

## Test Rounds

In early summer 1999, the first joint tests were carried out, labeled "Round1J" ( J = Joint ). During the initial round of testing, which was concluded with a meeting held July 7 and 8, 1999 at PROSTEP in Darmstadt, with the following vendors (CAD systems): AliaslWavefront (Autostudio), AutoDesk (Mechanical Desktop), Bentley (Microstation), Dassault Systèmes (CATIA V4), debis Systemhaus (CATIA V4), Matra Datavision (Euclid), PTC (Pro/Engineer), SDRC (I-DEAS), StepTools (ACIS), Theorem Solutions (CATIA V4) and EDS (Unigraphics) took part.

The testing activities started out with the improvement of rather basic capabilities. The Round1J Test Suite document defined surface models, solid assembly models, colors & layers and draughting as the testing scope. In order to arrive at stable production version of the STEP processors with those basic capa-bilities in a timely manner, the CAx-IF started off with three test rounds per year, which were reduced to two rounds per year in 2002 after this was accomplished. Currently, the 24th Round of Testing is being held.

After the previous test round has been evaluated and the neces-sary documents have been updated, each test round starts with the pre-processing phase, where the test models as defined in the Test Suite Document are exported to STEP and checked for syntax and compliance with the Recommended Practices, followed by the post-processing phase, when those STEP files are imported back into the CAD systems to compute the results of the data exchanges. These results, and the ongoing discussions of technical approaches, define the agenda for the review meetings held to conclude each round of testing.

For a long time, the testing evaluation was done using complex spread sheets which were cumbersome to maintain and rendered results only after all data for a certain test case was entered and cleaned up. Starting in mid-2007, this process was replaced with a web-based testing data base, CAESAR (CAx-IF Evaluation,
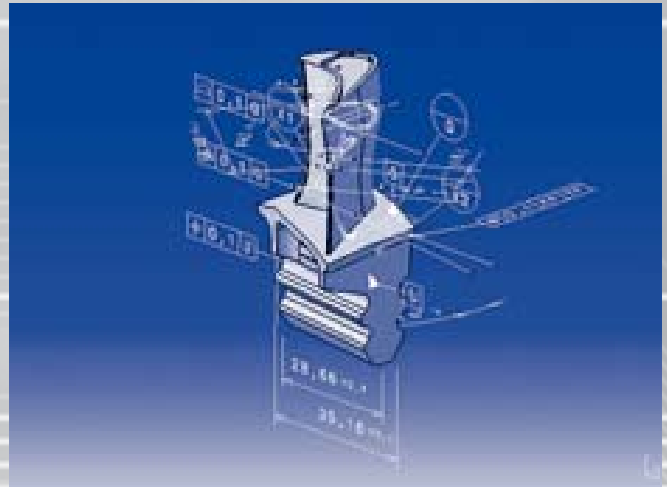
*One of the current CAx-IF test models including 3D Presentation of Product Manufacturing Information, which is relevant for long-term archiving and downstream processes.*

Statistics And Results). The participants can now enter their test data online and receive immediate feedback on the results, allowing them to fix issues already during a test round, hence speeding up processor development. The database is also extensible to support evaluation of the new functionalities currently under development.

## Tested Functionalities

The two major tasks of the CAx Implementor Forum are improving the quality of the STEP-based data exchange, and the extension of the scope supported by the STEP processors, based on user requirements. This is reflected in the scope of each round of testing by the fact that the test models usually are divided into two classes, production-like and synthetic test models.

Production (or production-like) models are usually provided by user companies where these models pose challenges during data exchange. The native models then are, under the terms of the non-disclosure agreement, exported to STEP by all participants offering a processor for the originating CAD system, analyzed, and imported with the intention to optimize the processors so that they can better deal with comparable models. The issues found during the eight ProSTEP Benchmarks were fixed in the same manner.

Synthetic test models as a general rule are geometrically simple models designed to test a specific functionality. While the testing procedure is the same, the evaluation focuses on the development, verification and improvement of the capability in focus. This usually goes along with the writing for the related Recommended Practices.

The STEP functionalities established so far include the "Geometric Validation Properties" to verify the success of the data exchange after import into the target application, "External References" to separately handle assembly structure and part models especially in large assemblies, "Colors, Layers and Groups" to improve visualization and organization of the CAD model and "Associative 3D Text" to support model annotations. Further information on these capabilities can be found on the CAx-IF homepages under "Joint Testing Information". (see: http://cax-if.org/joint_testing_info.html)

## Current Development

The current work of the CAx-IF is characterized by user requirements originating from two major business areas. With the rise of cross-disciplinary model-based processes in the industry, the exchange of data with domains beyond mechanical CAD, such as electric/electronic or machining applications is of increasing interest. Capabilities currently under development in this context

| Vendor | System |
| --- | --- |
| Adobe | Acrobat3D* |
| Autodesk | Inventor |
| CostVision | CostVision |
| Dassault Systèmes | CATIA V5 |
| DataKit | CrossCAD* |
| DataKit | OpenCascade |
| ITI Transcendata | CADfix* |
| ITI Transcendata | CADIQ* |
| Kubotek USA | KeyCreator |
| PTC | CoCreate Modeling |
| PTC | Pro/Engineer |
| Siemens PLM Software | NX |
| Siemens PLM Software | NX I-DEAS |
| Theorem Solutions | Cadverter* |

\* these are data exchange tools supporting a variety of CAD systems each, including CATIA, Pro/Engineer and NX

**During the 10 Years of CAx-IF…**

- …143 Test Cases were tested in 23 Test Rounds
- …35 STEP processors developed by 17 companies for 20 CAD systems participated
- …15 Recommended Practices were written
- …907 STEP files were exchanged with a total file size of 1,703 Megabytes
- …more than 10,000 emails were written

include the exchange of supplemental geometry, such as the definition of tool targets, and user defined attributes to transport non-geometric properties of the model.

The second major area of work is related to the long-term archiving of CAD data. In order to ensure access to the full definition of a model independent from the originating software (and hardware), comprehensive processes and data models need to be defined. In addition, the various standards for Digital Product Definition such as ASME Y14.41 or ISO16792 need to be supported. In close cooperation with the LOTAR International project, jointly facilitated by the AIA, ASD-Stan, PDES, Inc. and ProSTEP iViP, the CAx-IF helps to implement the capabilities to transfer Product Manufacturing Information (PMI), and extend the STEP standard where necessary to support this. The transfer of PMI includes both the machine-readable representation, as well as different approaches for the human-readable presentation of dimension, tolerances, notes and other properties.

## Outlook

During the past ten successful years, the CAx-IF concentrated on the development and improvement of mechanical CAD data exchange via STEP. This functionality has become an established data format in a wide variety of business scenarios around the globe.

The challenge for the future work of this Implementor Forum lies in the testing and support of precise data exchange over time and across domains. This can be accomplished by increasing

today's scope of mechanical CAD data exchange. The ongoing integration of PMI, PDM and parametric information will help to strengthen the position of STEP as a means of data exchange and storage independent from applications and over a long period of time.

The current development of the STEP standard toward a more flexible data model renders the opportunity to include data both from and for other domains. Some examples are composite material definitions, kinematic information, tool paths and material data. This data cloud be accessed selectively by a wide variety of applications such as electric/electronic, engineering analysis or costing tools. This would in turn open the CAx-IF for a wider group of participants. The group is looking forward to an interesting and prolonged future. ∎

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