STEELBASE - IMPLEMENTING PRODUCT DATA EXCHANGE FOR CONSTRUCTIONAL STEELWORK

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ABSTRACT

The paper describes the status of and the results from the Finnish SteelBase project in implementing standardised product data exchange for steel construction. The main application area of the project is the exchange of constructional steelwork data from the structural designers to the fabricators. The enabling technologies and specifications for the project are the STEP product data technology emerging from ISO TC184/SC4 work, and the results from the European CIMsteel-project. The paper describes SteelBase by the scope, methodologies and technologies used, as well as the developed implementation.

Keywords: product data technology, data exchange, constructional steelwork, SteelBase.

1 INTRODUCTION

The Finnish *FINNSTEEL* technology program of the Finnish constructional steelwork industry and the funding body Technology Development Center (TEKES) aims at the promotion of steel construction in general, and more specifically at decreasing of building costs and construction project lead times, and the promotion of the exports of constructional steelwork. The objective of the *SteelBase*, a project within the FINNSTEEL framework, in particular is to develop and implement neutral data exchange for constructional steelwork. The SteelBase project is coordinated by the Finnish Constructional Steelwork Association (FCSA) with some thirty partners from the industry: fabricators, designers, etc. The focus of the SteelBase data exchange is especially in the exchange between the structural designers and the fabricators.

The underlying driver for the SteelBase is to aim at neutral, standard-based, product data exchange which streamlines the information logistics of the design/manufacturing process, and increases the possibilities to exploit the constructional steelwork product data in digital form in the downstream activities, like production planning and fabrication.

2 THE ENABLING TECHNOLOGIES AND SPECIFICATIONS

2.1 STEP product data technology

The basic technology that SteelBase is utilising is STEP product data technology (ISO 1994a). It can be defined as a set of information technology (IT) methods, tools and standards for the development and implementation of computer applications for the management, exchange and sharing of product data in digital format. The main effort in the development of the product data technology (PDT) has been the international standardisation work in ISO TC184/SC4 *Industrial Data* committee. The main result from the work so far has been the so-called STEP-standard, officially known as *ISO 10303 Product data representation and exchange* standard.

The kernel of the STEP methodology includes:

- Description methods for describing (using formal information modelling techniques) the product information to be exchanged; the central method being the EXPRESS data specification language (ISO 1994b).
- Integrated resources as a set of reusable product data constructs to be used in the development of application domain specific data exchange standards.
- Application protocols which are typically industry specific data exchange standards to support specific data exchange needs. Application protocols are the data exchange specifications to be implemented by software vendors as pre and post processors for neutral data exchange, and to be used in the practical data exchange.
- Implementation methods providing the definition for a neutral data exchange format for file based data exchange (ISO 1994c), and a standardized data access interface for product data repositories.
- Methods for the conformance testing of implementations.
- A formalized standardization process according to which data exchange standards (Application Protocols) for new areas can be developed.

The formal modelling methods of STEP methodology have also resulted in commercial toolkits for the development of STEP implementations, e.g. product model browsers and CAD pre and post processors. Using the formal product data descriptions the tools provide applications programming interfaces (APIs) for parsing, reading, writing data, and data access. All this is driven by the EXPRESS description of the product data.

The fundamental principles of STEP data exchange are outlined in *fig.1*: STEP defines mechanisms for neutral data exchange, i.e. in the data exchange the product data is in the form defined by STEP standards and the sending and the receiving applications have pre and post processors to convert the data from their own data structures to this neutral format and vice versa.

The other important principles is that the product data to be exchanged is formally described using information modelling techniques and EXPRESS data specification language. Once the data is described in an EXPRESS schema or product data model, the STEP implementation methods define encoding rules, i.e. syntax for the exchange format, for the product data to be represented in a data exchange files. Also a data access interface has been defined for standardized data access between applications and product data repositories.

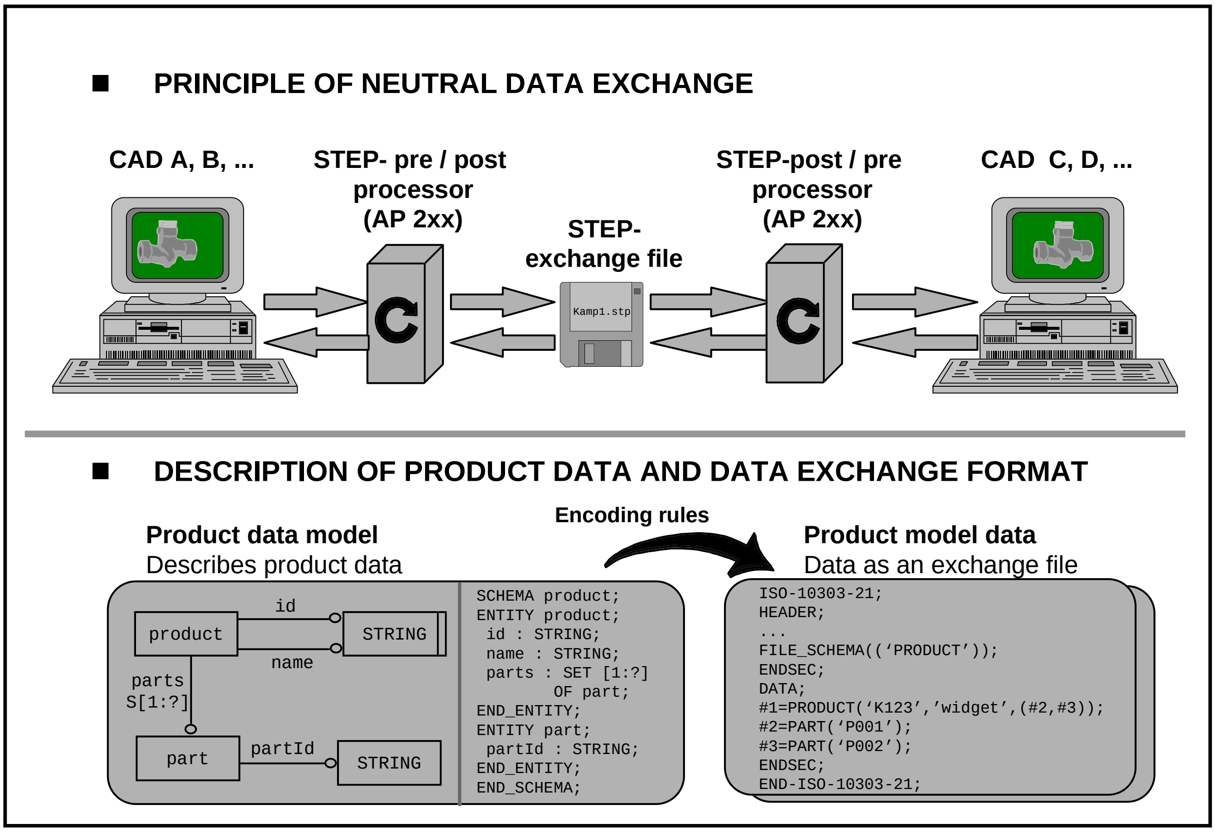

Fig. 1. The principles of STEP data exchange.

2.2 CIMsteel Integration Standards

The other enabler for the SteelBase aims are the results from the European *Eureka* project *CIMsteel*. The CIMsteel project has defined a data exchange specification, the so-called CIMsteel Integration Standards (CIS 1997), for the exchange of constructional steelwork product data. In its developments CIMsteel has, on the other hand used STEP product data technology, and on the other hand the CIS-standard will provide the basis for the development of an international STEP data exchange standard or Application Protocol for constructional steelwork (AP 230: *Building Structural Frame: Steelwork*, WWW-AP230).

The main component of the CIS standard is the Logical Product Model (LPM), which is a product data model for constructional steelwork, and it is represented using the EXPRESS-language. The LPM is divided into so-called Data Exchange Protocols (DEP), which are subsets of the LPM, to address specific data exchange needs in the design and manufacturing process of the constructional steelwork. Currently in the CIS Release 1.1, there are four DEPs, namely DEP1 *Analysis*, DEP2 *Member design*, DEP3 *Connection Design* and DEP4 *Detailing*. The CIS standard also defines mechanisms for identification of standard items, like materials and profiles, and for conformance testing of the applications.

3 STEELBASE COMPONENTS

In its developments of neutral product data exchange for constructional steelwork SteelBase is using existing or has defined a number of new components:

- A data exchange specification, for which CIMsteel LPM DEP 4 is being used with some additional Finnish flavouring.
- Standard item referencing codes, where the basic mechanisms are as defined by CIMsteel with some added codes for typical Finnish standard items.
- Standard report types, which is an attempt to standardize the typical bill-of-material reports exchanged between for instance the designers and fabricators. Eight different report types were defined: list for inquiry of materials, list of assemblies on site, single part list, list of fasteners etc.
- *StBrowser,* a product model browser and converter, which is a simple computer application to support the data exchange and exploitation of steelwork product data.

4 THE STEELBASE MODEL = CIMSTEEL DEP4 WITH FINNISH FLAVOURING

4.1 CIS DEP4 with Finnish flavouring

After a study among the candidate models the SteelBase project decided to use the CIMsteel CIS data exchange specification for the exchange of constructional steelwork product data. More precisely, the data exchange is based on the CIMsteel Integration Standard (CIS R 1.1), its Logical Product Model LPM V4.0, and Data Exchange Protocol DEP 4 *Detailing*. The focus of the exchange is the data transfer from the structural designer to the fabricator. An informal model of the main units of functionality within the scope of SteelBase are shown in *fig. 2*.

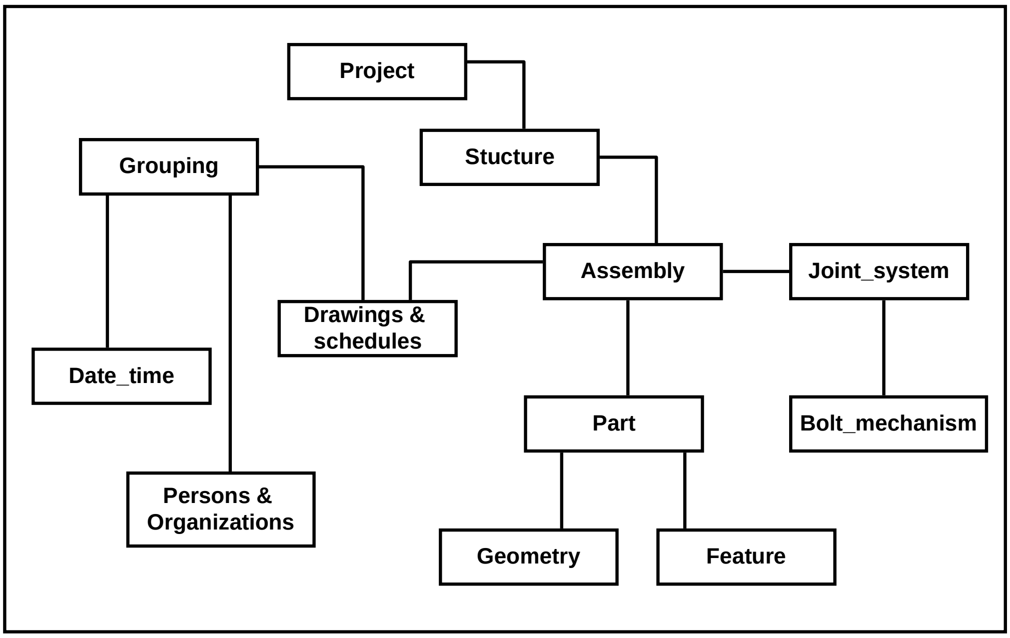

Fig. 2. A rough information planning model for the scope of SteelBase product data model (a superset of CIMsteel Logical Product Model LPM V4.0, Data Exchange Protocol DEP 4).

To meet the industry needs for the data exchange within the scope for SteelBase some modifications to the CIS DEP4 was done. Firstly, some additional entity types which are not mandatory in official DEP4 were brought into the SteelBase scope. These entities are still from LPM, but outside of the scope of DEP4. The scope ofthe SteelBase includes 55 entity types, while the full LPM has 121 entity types. Secondly, identification codes for some often used standard items (material, profiles and fasteners) were defined. An example of a standard profile reference is:

```
\S\SECT\EU\CFC120.0*60.0*6.0\SFS5484\
```

Thirdly, an encoding mechanism was defined for those information requirements not addressed by LPM. The encoding of the additional information was needed because SteelBase wanted strictly to formally conform to the LPM-schema. While the schema also defines the data exchange file format, the SteelBase data exchange files qualify as DEP4 data exchange files. So, the changing of the schema was out of question. The encoding mechanism used by SteelBase is to define fields with identification by a key and field separator within attributes of string data type of entity types. Typically, the main components (entity types), like *manufacturing assemblies* and *located parts* of DEP4 have a description attribute which are by SteelBase used for holding the encoded data. The encoded data include data elements like part weight, paint area, wholesaler code etc. An example on a coded description value could be:

```
'\D=HQ-PALKKI_BLANK\M=HQ265-5-15/215-10/350\P=6.90\T=1201-1\W=412.\'
```

4.2 Data exchange formats and stardard reports

The basic data exchange format for SteelBase exchange is the STEP Part21 file format (ISO 1994c), based on the DEP4 EXPRESS schema. Additionally, some new and existing exchange formats were defined and are used. For simplified data exchange the so-called *StB*-model was defined to exchange basic bill-of-material data. The fabricators defined their own *TXRec*-format for importing data into the production planning systems. The German DSTV NC-format (DSTV 1997) will be used for steering the numerically controlled machine tools, e.g. for automated cutting of profiles and hole boring.

The StB-format is basically the STEP Part21-format, which is defined by a simple EXPRESS-schema capturing the information requirements of typical bill-of-material reports. Actually, the standard report types defined by SteelBase were the baseline in defining the StB-schema. It has only five entity types for representing project, manufacturing assembly, located part, some fastener, and document administrative information. The very purpose of the StB-model and data exchange format is to support data exchange from applications other than the sophisticated model-based CAD applications which represent enough information to populate the full DEP4 schema. StB data exchange tries to provide a migration path from for instance CAD draughting systems into the full steelwork product models with comprehensive product description and complex relationships.

The TXRec-format is different from the SteelBase STEP Part21 format only by syntax; the data content is the same as that of DEP4. The TXRec syntax uses concepts similar to relational database concepts, like records, fields and foreign keys for relationships. The syntax makes it fairly easy to map the data into relational databases, and because of the named fields in the exchange file, also extensions to the format and skipping of unknown data elements is possible.

Below is an extract from a TXRec file, where *R-* starts a named record and each value field has a name and value:

```
…
R-MANUFACT_ASBLY
-PGR=14713472
-ID=TUT-3
-STAGE=SHOP
-GRP=TUT-29
-TAG=TUT-P001
-DES=COLUMN
-L=0
-H=0
-APA=0
-WEI=0
-SURT=SFS4962_A_80/2-Fe_Sa2
-SURTC=KY2
-SURTF=NA
-POF=TUT-2
R-MANUFACT_ASBLY
-PGR=14713472
-ID=TUT-4
-STAGE=SHOP
-GRP=TUT-29
-TAG=TUT-P001
-DES=COLUMN
-L=0
-H=0
-APA=0
-WEI=0
-SURT=SFS4962_A_80/2-Fe_Sa2
-SURTC=KY2
-SURTF=NA
-POF=TUT-2
…
```

The standard report definitions of SteelBase concern the paper-based exchange of steelwork data. *Fig. 3* shows an example of a standard report generated from the product model.

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Text99:MASSALUETTELO TERÄSRAKENTEIDEN TARJOUSKYSELYÄ **Dwg no of list:**
RAK-2609-9991 **15.1.199 8**
VARTENText99:
LIST FOR INQUIRY OF STEEL STRUCTURESText99: According to dwg RAK-2609-001 Yritys: Company: KPM-Tamecon Oy

Proj nro: Project no: 2609 Yritys Company KPM Suunn.nimi: Name of LAURILA

Projekti: Project: HALLI PIETARI / 11000 M2

Luet.tied: List file: Tietokanta: Database: c:/ACAD/2609/*.osa c:/ACAD/2609/*.osl Viim.rev./pvm: Last_rev/date: Luett. luontipvm: Creation_time_of_list 1997-10-10

Tunnus ID	Rakennelaji Member name	Materiaalinimike Material code	Teräslaji Grade	Kpl Pcs	Pituus /kpl Length/ pc. (mm)	Paino /kpl Weight /pc. (kg)	Kokon. paino Total weigh (tot.kg)	Maal. p.-ala Paint area	Tukkukaup. koodi Wholesaler's code	Huom! ATT!
101	PILARI		S355J2G4	10	0	270	2700	5,48		LKM: 10
101	PILARI		S355J2G4	10	0	270	2700	5,48		LKM: 10
102	PILARI		S355J2G4	10	0	254	2540	5,7		LKM: 10
102	PILARI		S355J2G4	10	0	254	2540	5,7		LKM: 10

Fig. 3. Bill-Of-Material report example generated from the product model.

5 SOFTWARE IMPLEMENTATION

5.1 StBrowser - product model browser for constructional steelwork

A product model browser and converter, called **StBrowser**, was and is being further developed by SteelBase. The purpose of the StBrowser is to:

- Support the steelwork product data exchange in digital form by providing a tool for navigation and viewing of the product model data, especially in the receiving end of the exchange.
- Support exploitation of steelwork data by providing reporting facilities for the generation of standard report types from the product models, and by providing conversion services for exporting the data into TXRec and DSTV NC formats.

- Support migration of data from the current draughting applications into the steelwork product data by providing mapping services from the simple StB model into more complex SteelBase (DEP4) model. The mapping is based on some rules on how the missing information of the SteelBase model is automatically generated from the StB model.

The StBrowser system overview is shown in *fig 4*.

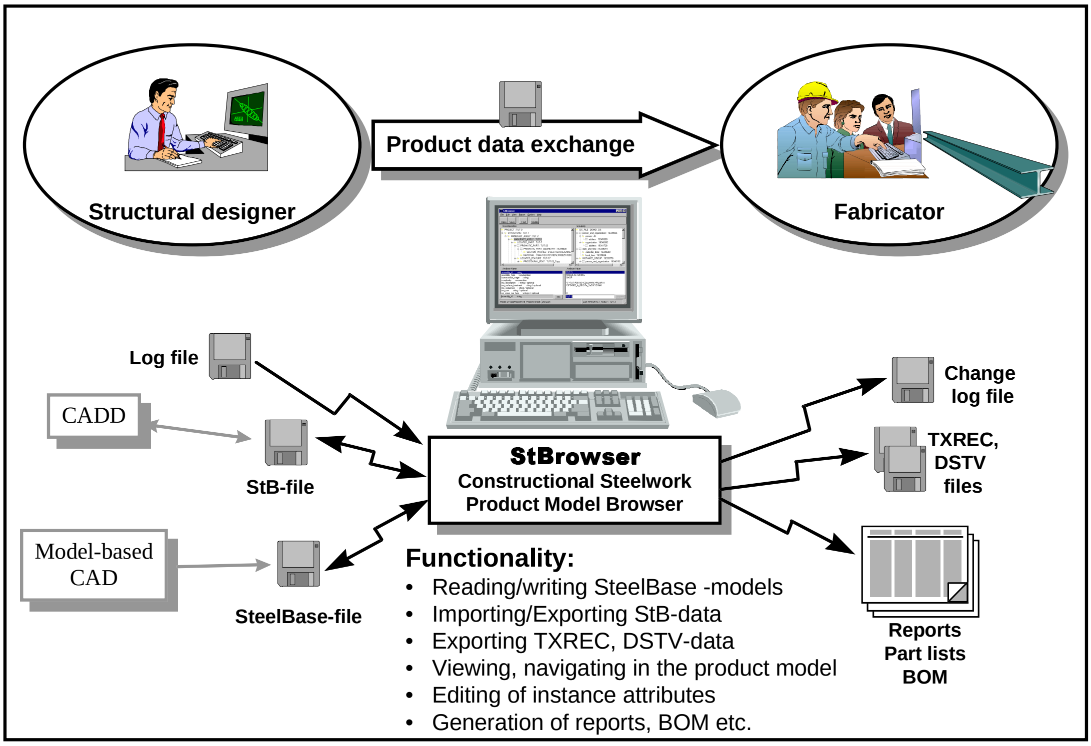

Fig. 4. StBrowser system overview.

The functionality of the StBrowser include the following:

- Reading and writing SteelBase files (i.e. CIMsteel DEP4) , which is the basic data storage form for the StBrowser.
- Importing and exporting of StB-files by mapping them to and from the SteelBase model.
- Exporting of TXRec and DSTV NC (under development) files.
- Viewing and navigating in the product model.
- Simple editing of instance attribute values. The editing of standard item references is supported by a database of standard codes for material, profiles and fasteners.
- Checking of the product model data against the constraints defined by the schema.
- Generation of the bill-of-material reports from the model data.
- Logging of model history (mainly attribute editing) into a log file, which tries to provide a primitive change management mechanism for the models.

Fig. 5 shows some extracts of the StBrowser user interface.

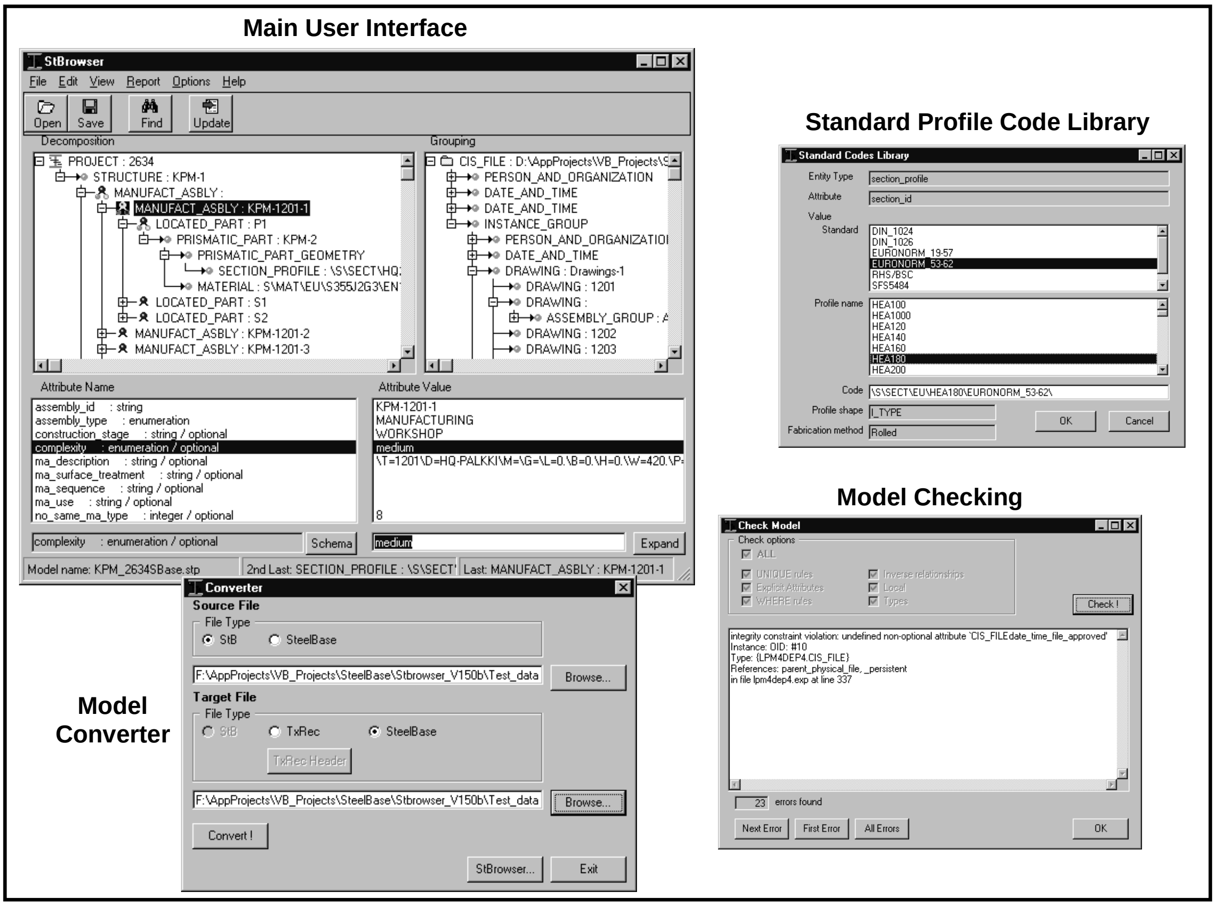

Fig. 5. StBrowser, product model browser, user interface.

5.2 Implementation technologies

In the development of the StBrowser application which is running in PC Win'95 and NT platform, a number of technologies is used: the STEP back-end which provides the data access interface for STEP data is based on a commercial STEP toolkit, namely *ST-Developer* from STEP Tools Inc. (WWW-STI). Also, another STEP toolkit is used for a specific purpose: the *ECCO Toolkit* from Karlsruhe University (Staub & Maier 1996, WWW-ECCO) is used as a model checking server for checking the model data for the conformance with EXPRESS rules or constraints. The basic programming of the application is done using MS Visual Basic and C++. For reporting purposes a MS Access database is used: firstly the data needed in the reports is exported as a batch operation from the product model into the database. The database then contains predefined queries and report definitions to produce the standard reports from the data.

Because of the use of the STEP toolkit which automatically compiles the EXPRESS schema into a data access interface, the StBrowser implementation is actually based on the full LPM model, not just the DEP4 subset. This means that the implementation is able to read and write product model data of all the DEPs, from DEP1 through DEP4.

6 STEELBASE STATE OF DEVELOPMENT

SteelBase project is now in its second phase, and third phase is being planned. The first phase of SteelBase defined the data exchange specifications and made the initial implementation of the StBrowser. The second phase extended the StBrowser implementation to be fully based on CIS DEP4, and currently the DSTV NC converter is being finalised. Also, one engineering company has implemented a StB pre processor for producing StB exchange files from a steel draughting application which is developed on the top of AutoCAD. The commercial DEP4 pre processors for model-based steel-CAD applications are still lacking, but being planned.

The SteelBase work has also included involvement in the standardization efforts, in the form of contributions/commenting of the information requirements from the industry to the CIMsteel and STEP AP 230 developments. Currently, the participation of the SteelBase in the work of International Alliance for Interoperability / Industry Foundation Classes (IAI/IFC, WWW-IAI), and especially in the *ST-1 Steel frame* project is in the planning phase. The project would develop interoperability mechanisms between the CIMsteel and IAI/IFC specifications.

7 DISCUSSION

The experiences of the SteelBase project so far have demonstrated that the product data technology, including the methods for the specification of product data models, implementation support from the toolkits and actual data exchange specifications in specific domains, has matured to the level where realistic product data exchange solutions can be strived for. Yet, the data exchange specification development for comprehensive AEC data exchange will still be an ongoing effort (e.g. in IAI and STEP) for some time.

Furthermore, experiences demonstrate in a small scale the difficulty of taking practical technologies into next higher level; here for example going from document data exchange into product data exchange. This often requires co-existence of many parts of the puzzle, like data exchange specifications, implementation tool support, commercial software implementation, migration support for legacy data, producers and users of the new product data, willingness for process changes.

Finally, the software implementation of the SteelBase may perhaps serve as a modest proof of the fact that product data technology has evolved to the level where it can be linked even with standard office applications – to bring ***product data for every desktop*** **!**

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