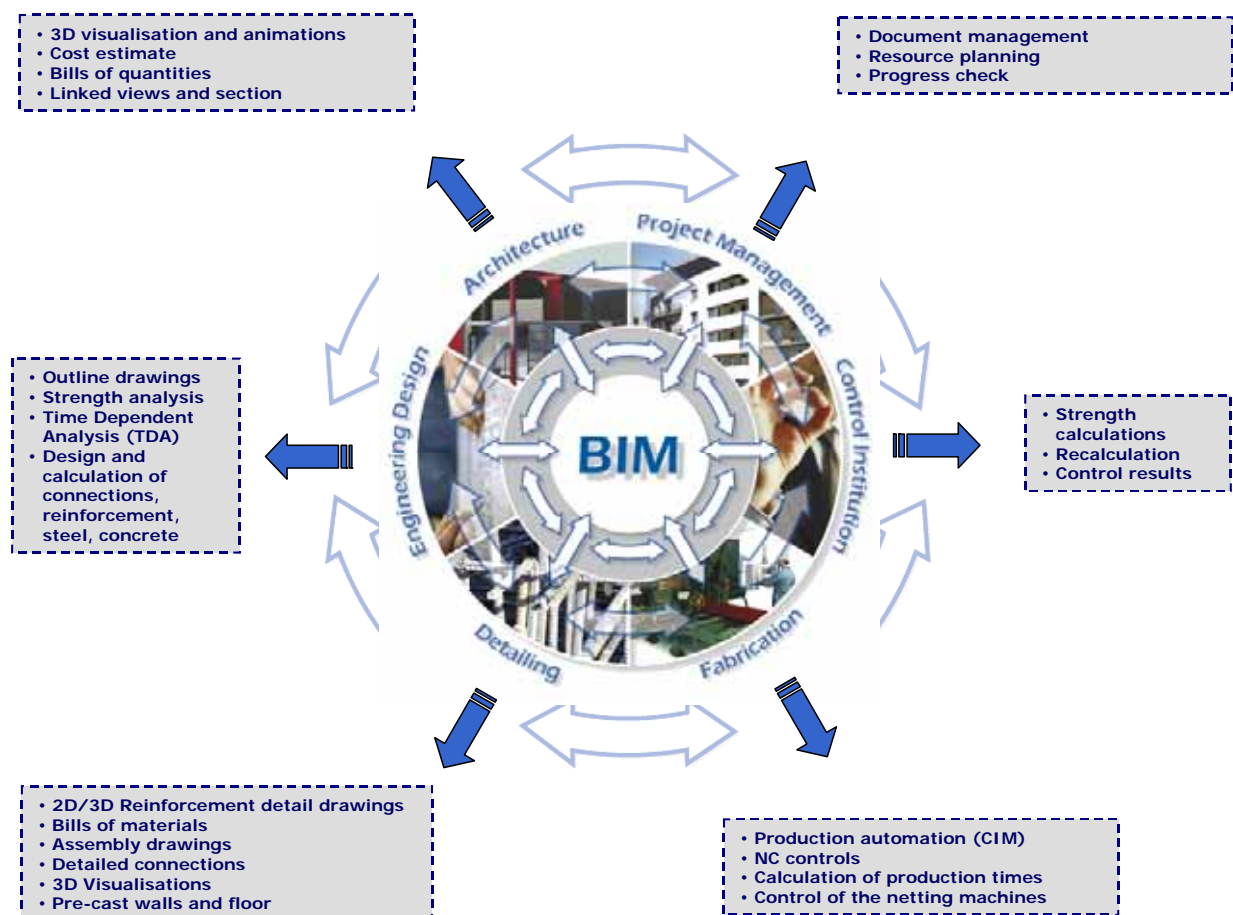


This paper clarifies the technology of Roundtrip Engineering being developed by the companies SCIA and Nemetschek in relation to other collaborative techniques (e.g. IFC) adapted in current B.I.M. (Building Information Modelling). Practical examples illustrate the efficiency of roundtrip engineering in industrial applications for constructions.

## 1. Interoperability

A major breakthrough is being achieved in the construction world through better coordination of multiple disciplines; construction information throughout the entire building cycle is being shared by applying B.I.M. (Building Information Modelling). Adopting 3D models will lead to better documentation (drawings, reports, quantities, ...) and to collaboration by transferring models from one construction partner to the other. A schematic view on BIM collaboration is sketched hereafter.



Many activities from different construction partners are linked through a 3D model based information exchange. The BIM concept has the advantage that partial solutions (e.g. a link between detailing and fabrication, or a link between architectural models and engineering design models) bring immediate results.

## **2. IFC link between CAE and CAD**

Considering the variety of software applications in use by engineers and architects, international efforts are underway to define a methodology to exchange as much information as possible. One major initiative comes from the International Alliance for Interoperability (formed in 1995) and is named I.F.C., Industry Foundation Classes. IFCs describe the building model, its components, and the relationships between them in single model shared by diverse applications. Currently IFC version 2x edition 3 is supported by a large number of software authors, such as Autodesk, Graphisoft, Nemetschek, Robobat, Tekla, Bentley and also SCIA. Yet one must understand the IFC import / export implementations of the various software companies:

- there are several “domains” in the IFC exchange format; concerning construction we mention architectural domain, structural domain, analysis domain and detailing domain.  
Most software vendors only address one or two domains within their data representations.
- the functionality of the foundation classes and objects is permanently enhanced: e.g. more structural objects for foundations are added. A complete description of a structural model readable by all software vendors will take a lot more time. Especially more advanced modelling data are not yet described: e.g. steel reinforcement models in the structural model are still limited, etc...
- IFC allows for import and export of model data; there is not an automatic update mechanism; it is however possible to provide proprietary update tools to allow updates of objects, which are present in two different applications accessing the UUID (Universal Unique Identifier). The tool is such that a correct action is taken to update an object, remove it, add a new one, etc.
- Models are imported and exported coming from the same domain: e.g. an architectural model will be exported to another application that also reads architectural models.

We are convinced that every serious software developer for the construction industry must support at best the IFC. Nemetschek and SCIA are active members in the IFC workgroups. In several software modules of both companies the various IFC domains are gradually being implemented (architectural views, structural view, analysis view, detailing view).

Nemetschek supports IFC 2x3 architectural view (release Allplan 2006)

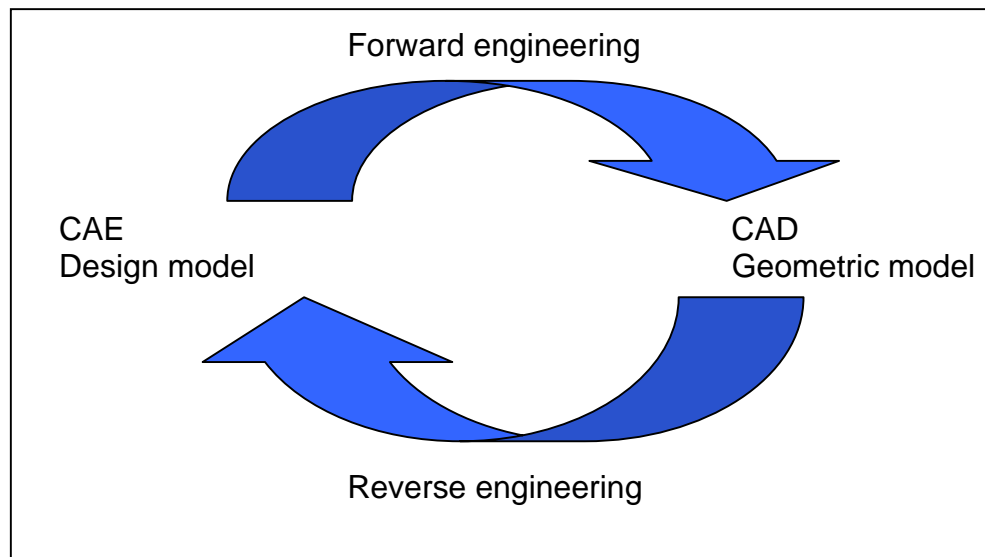
SCIA supports IFC 2x3 structural view (release SCIA • ESA PT 2006.1); within SCIA • ESA PT the structural model generates automatically an analysis model.

Between Allplan (archit. view) and SCIA • ESA PT (structural view) a direct link (with roundtrip engineering, see further) is being implemented.

Most CAE software suppliers only support the IFC 2x3 analysis model, which enables transfer of data to other CAE packages. A link between models of the same domain is not a link between CAD and CAE as often is mistaken.

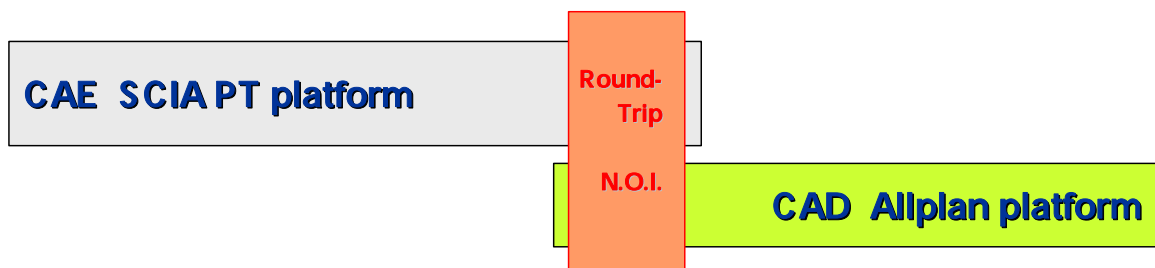
### 3. Roundtrip Engineering

An more integrated and advanced collaboration technology is named “roundtrip engineering”. Schematic, it is:



Practically every design of a construction is an iterative process of refining, reviewing, changing architectural, engineering or building (fabrication) details. Therefore a roundtrip solution, where a designer or detailer can start or edit the model at any stage, is closest to reality and will lead to the shortest time between design and fabrication or building. Reverse engineering reconstructs the design model from the CAD geometrical model, again an extra benefit.

Roundtrip engineering is being achieved by SCIA through a joint development with Nemetschek of a common interface between two platforms, one for CAE and for CAD. Complex CAE calculations may be executed, hidden to the normal CAD user.

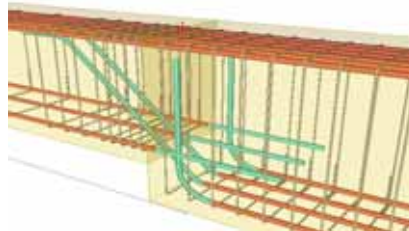


The SCIA PT (Professional Technology) platform addresses CAE modelling, with a consistent structural and analysis model for steel and concrete building parts & structures. The structural objects are directly linked with corresponding parts within the Allplan platform, using the Nemetschek Object Interface. Steel sections and concrete constructive elements are one-to-one compliant.

In contrary to a link based on IFC between models of a same domain, here a transfer between a CAE and CAD model is being realized (in both directions).

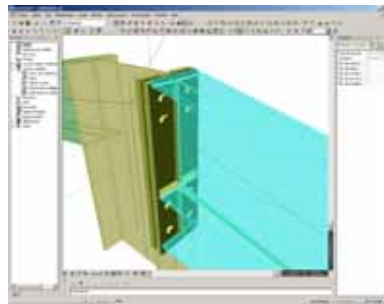
Roundtrip is much more than import / export. Some extra benefits which are being implemented:

- the upgrade engine keeps the CAE and CAD model compatible; outside data (e.g. design data) are stored as Blob (Binary Large Objects) properties
- labels remain positioned in associated views after changes
- refinements and changes are possible in selected parts of a construction; they will be transferred to the other application.
  - e.g. changing RC steel reinforcement hooks or diameters will lead to a fast redesign (or re-analysis)



RC model of a beam  
(Allplan) redesigned  
in SCIA • ESA PT

e.g. changing steel connection types lead to a redesign



Steel bolted connection  
adapted in Allplan Steel  
Design and recalculated  
in SCIA • ESA PT

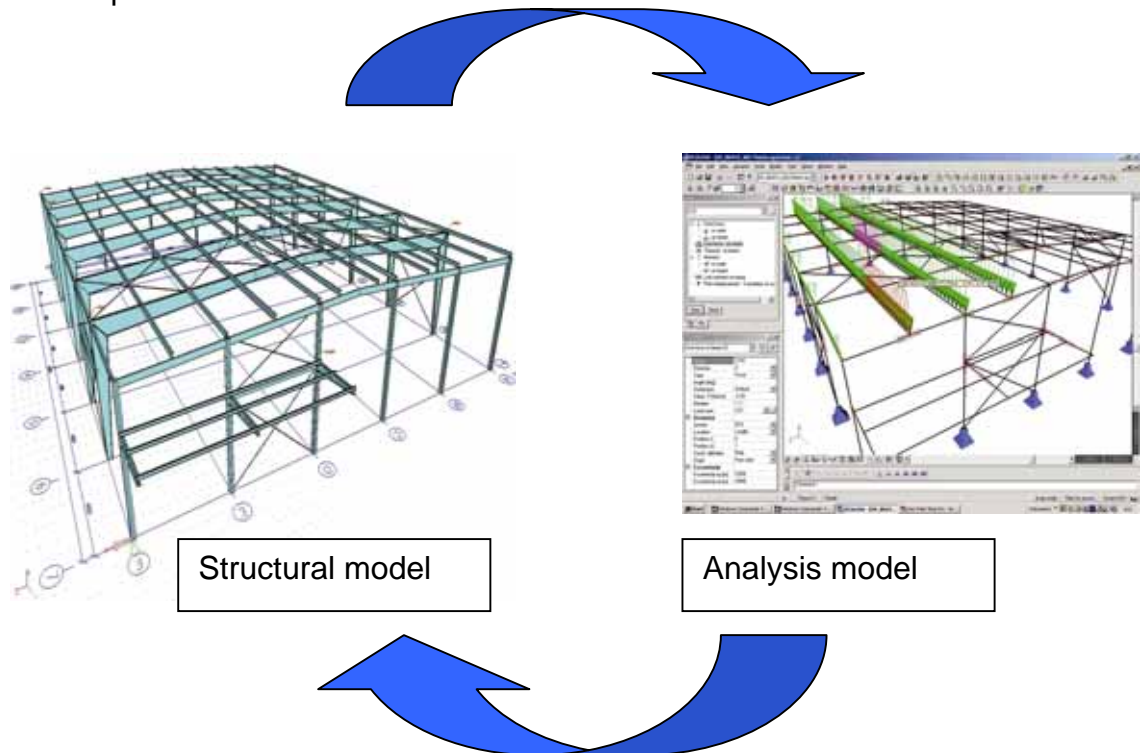
- fast modelling techniques in one platform are reflected in the other platform
  - e.g. parametric modelling of building parts (option in SCIA PT)
  - user defined templates (in SCIA PT)
  - copying, moving, mirroring (CAD functions) for engineering models (in Allplan)

SCIA is addressing the functionality of the Allplan platform concerning modelling of steel reinforcement.

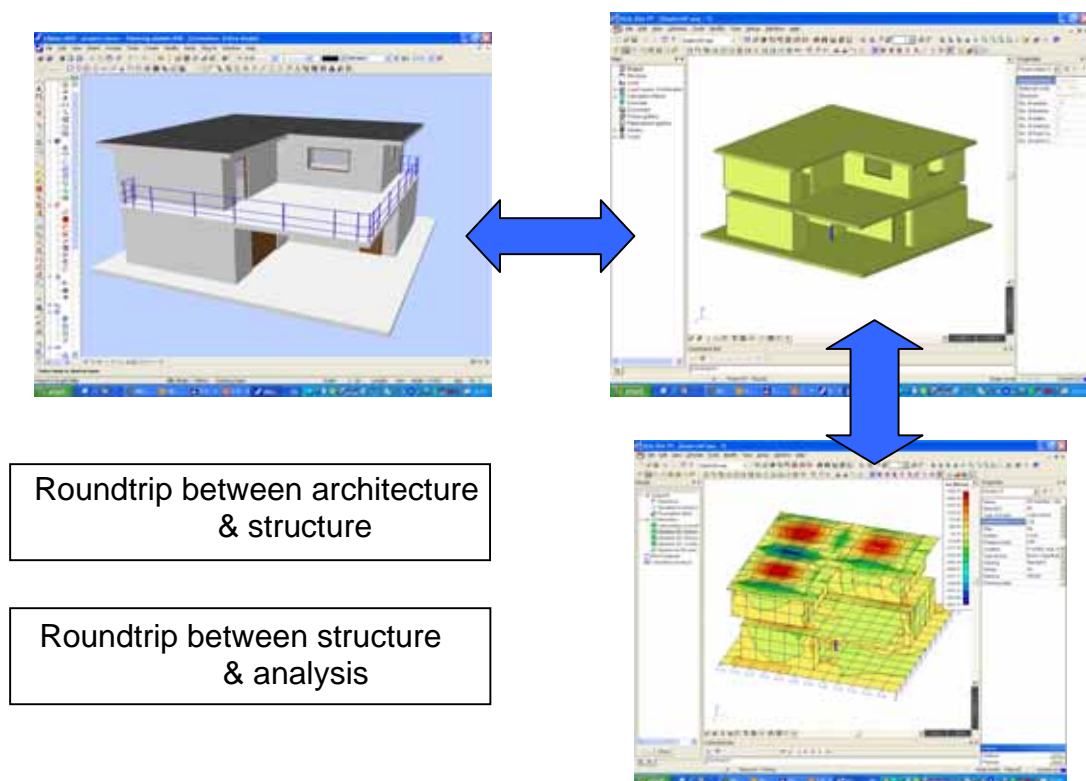
Also with other CAD modelling systems such as Revit (Autodesk) SCIA is implementing the highest functional link; Revit is providing an API (Programming Interface) that allows partly roundtrip engineering. With Revit Structures SCIA will have a link to the SCIA PT analysis model. It means that from Revit Structures the input of geometry and loading will be exported directly to SCIA • ESA PT. Changes to the structural model can be imported in the structural model of Revit.

The roundtrip process SCIA – Nemetschek is illustrated with 2 small illustrative examples:

- steel portal frame



- RC concrete structure

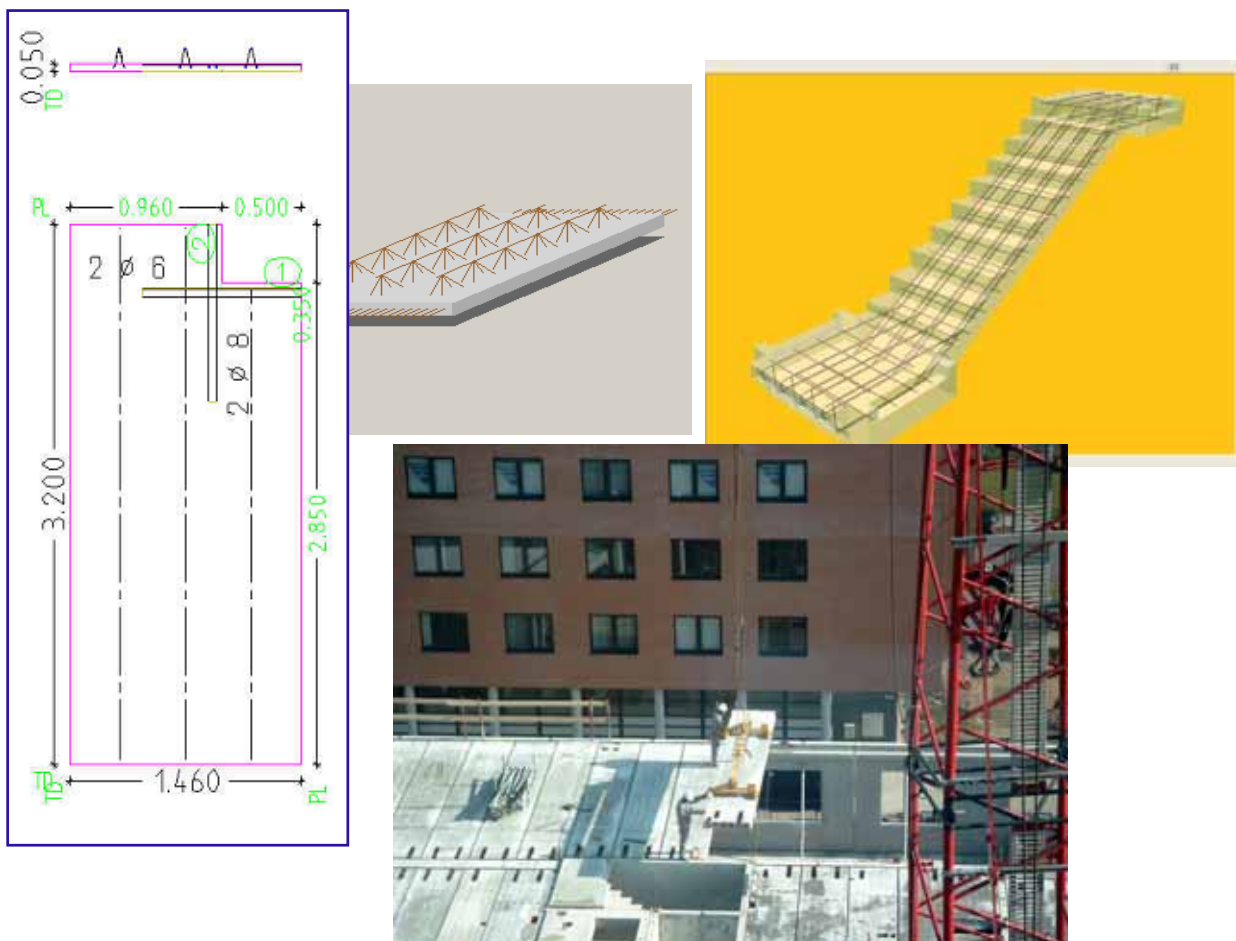


#### 4. From Design to Cost, to Build and to Fabrication

Roundtrip between analysis/design and geometric modelling is shortening the design process with great efficiency. Yet there is more: upon constituting a full model of the construction, a further benefit comes from automating the downstream activities to actually realize the project. The strength of an intelligent BIM model, as is built with a software suite as Allplan, is the integration of a lot of extra functionalities on the same platform. A brief listing:

- Quantity take-off
- Building activities lists
- Precast: automated fabrication drawings & full production planning
- Steel fabrication: automated overview drawings & material lists
- Construction planning: scheduling linked to the 3D model
- Facility Management: as built documentation, change management,
- Maintenance, etc.

The examples hereafter illustrate the precast functionality, incorporated in the Allplan platform. The interoperability is illustrated as follows: an architectural floor is divided in precast elements; the slab elements are calculated and reinforcement is generated; the production drawing of the slab elements are generated; the welding robots for meshes are steered. It becomes obvious that roundtrip engineering linked to automated fabrication software, gives a tremendous power to virtual simulation of “design to fabrication”.

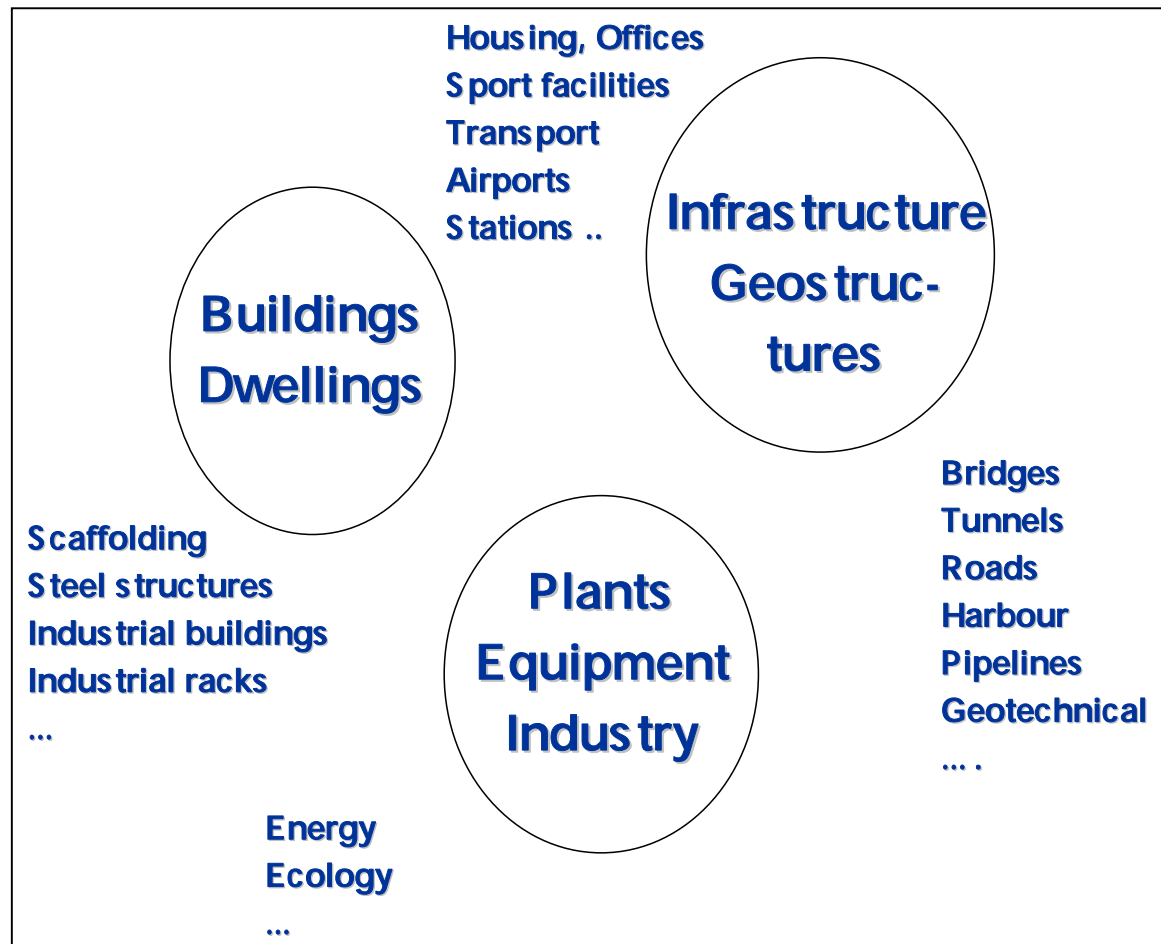




## 5. Construction Industry Solutions with roundtrip engineering

Construction is more than buildings and dwellings. Worldwide there is continuous need of building and renovating infrastructure (bridges, roads, harbours). Yet also in industrial equipment a lot of engineering design is going on.

In all market segments, yet specially in industry, a tremendous profit is achievable with dedicated roundtrip solutions.



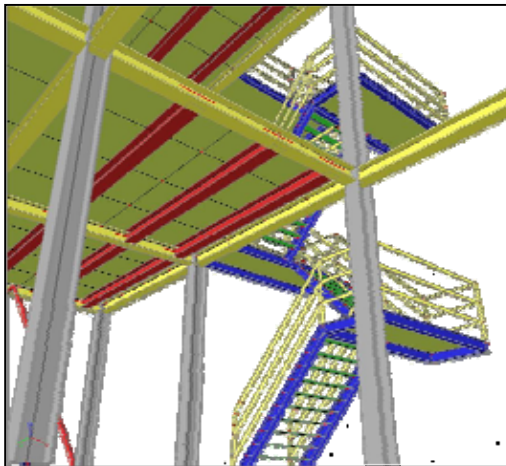
The success factors are due to a combination of factors:

- the time from client demand to proposal, and afterwards to delivery is very short
- as well drawings as engineering reports are to be submitted
- in the past standardisation (e.g. tables) was sufficient; now projects are customized
- in many cases repetitive structures (or parts) are used
- the construction preparation is much demanding (detailed drawings, list of materials, ...)
- link to logistics and ERP software is required
- structural safety is a major issue.

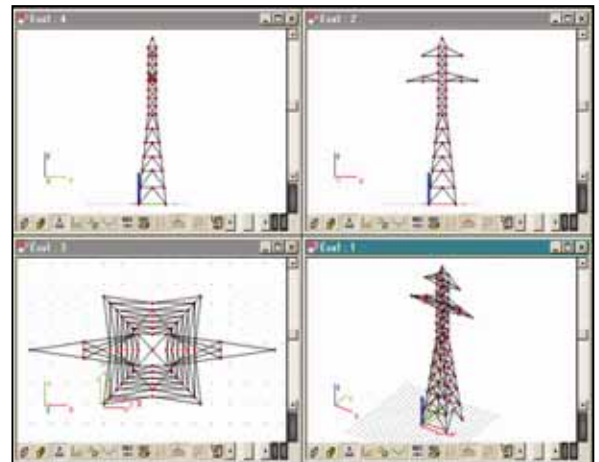
In recent years we have been involved in several industrial automation projects, where roundtrip engineering was a decisive factor. An overview:

- industrial racks (steel, aluminium)
- turnkey standard building systems in steel (example [www.astron.biz](http://www.astron.biz)) or concrete
- scaffolding
- plant design systems
- mast structures
- stands, temporary stages (concerts, sports)
- isolated roof systems
- tents
- ...

Rack



Plant design templates  
In SCIA • ESA PT



Electricity Mast templates  
In SCIA • ESA PT



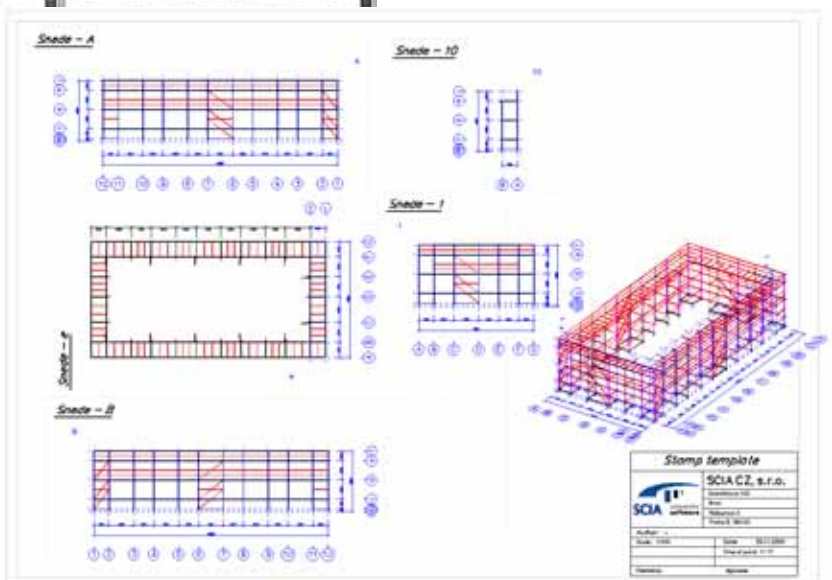
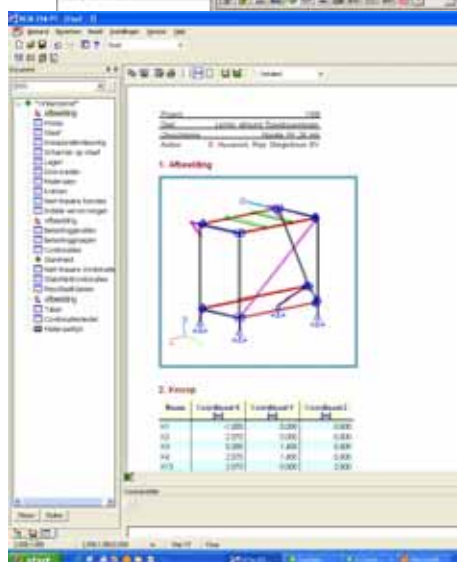
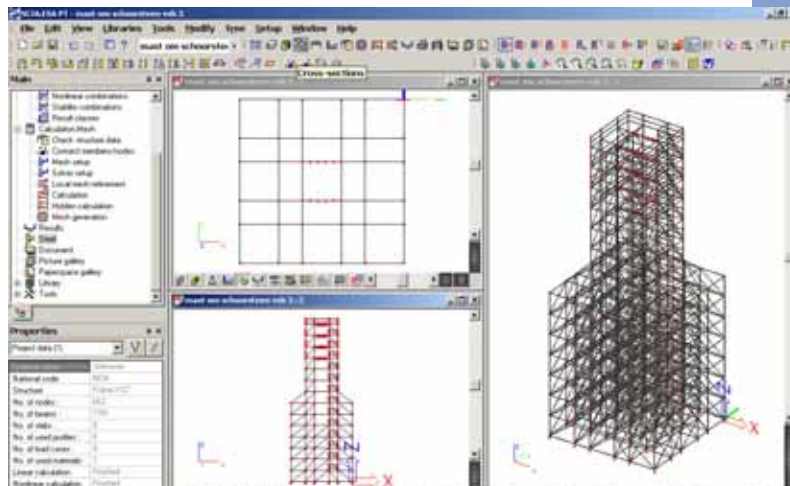
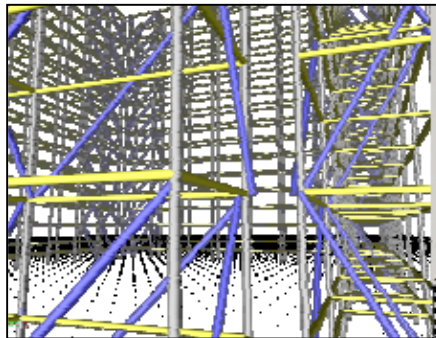
Self-carrying isolated roof  
elements



Tent structures in  
aluminium



A more elaborated illustration is given for scaffolding structures: all roundtrip aspects can be recognized: fast modeling (parametric building parts), safety structural analysis, automatically generated drawings & material (article) lists.



## **6. Conclusion:**

Roundtrip engineering is drastically improving the design process; it is the most advanced implementation of Building Information Modelling technology. Integrated open general CAE-CAD platforms provide customized solutions without the necessity of dedicated programming. Ease of use and far going automation are key elements of the success.

## **About SCIA**

SCIA is an acronym for Scientific Applications, a term that highlights its technological background. Founded in 1974, SCIA is a software company headquartered in Belgium, which develops, markets and supports software products for structural engineering in the construction market. SCIA's software is typically used to design and detail buildings, bridges, and other complex engineering structures, and is focused on the middle to high-end of the market. SCIA is the market leader in Benelux and Czech/Slovak Republics. It has an international network of branches and distribution partners in 15 countries. Its products have been translated in 8 different languages and have sold in excess of 7,000 licences to more than 4,500 clients in over 20 countries. SCIA is a member of the Nemetschek Group of companies since Feb. 2006.