Multi-Purpose Building Models for Switzerland

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SUMMARY

Information about buildings is a key resource in the business processes of a wide range of organisations. Today, in addition to data provided by the private sector such as Google Maps, Google Street View or OpenStreetMap, three different public sector databases are available nationwide in Switzerland. The three "products" - the register of building and dwelling (RBD), the (multi-purpose) cadastral data (CD) and swissBUILDINGS^{3D} - were created with different objectives and the data sets are currently not synchronised and harmonised. Within the framework of a study, the idea of a new product "Official Building CH" was investigated and different variants were elaborated.
International standards such as CityGML for comprehensive city models and Industry Foundation Classes (IFC) in the context of Building Information Modelling (BIM) are widely used in various sectors and could be used as the basis for a future "Official Building CH" database. However, an analysis of various research projects shows that the exchange on the basis of IFC does not generally function loss-free and is associated with manual cleaning. Likewise, no approach has yet proven to be ideal for the transfer from CityGML to IFC or in the opposite direction. Based on the goals of the data repository and the requirements for a user-friendly data model, the study therefore favours the variant of an independent, neutral model. With this approach, the aforementioned problems in the exchange between the BIM domain and the geodata infrastructure can be eliminated more easily.
For the proposed approach, a conceptual data model was developed at the class diagram level. Proposals for geometric modelling, data capture guidelines and proposals for tracking complement these specifications for a harmonised data structure. The data model was checked for plausibility based on various existing buildings. It was also checked that the recently published data model for the 3D documentation of condominium ownership corresponds to the proposed structures.
Based on the positive feedback from current and potential users of an "Official Building CH " repository, the project should be realised. According to statements by individual organisations, the timing is ideal, as many will be digitising their processes in the coming years and major changes are also imminent in the multi-purpose cadastre.

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1 INTRODUCTION

1.1 Current situation

Information about buildings is a core resource in the business processes of a wide range of organisations. Today, in addition to data provided by the private sector such as Google Maps, Google Street View or OpenStreetMap, three different public sector databases are available nationwide in Switzerland. The three "products" - the register of building and dwelling (RBD), the official cadastral survey (CD) and swissBUILDINGS3D - were created with different objectives and the data sets are currently not synchronised and harmonised across as a whole.
In the younger past, business processes in the planning, construction and operation of buildings and infrastructures, among other things, have developed a great dynamism through digitalisation, especially thanks to the BIM method. A steadily growing number of users are becoming aware of the advantage of structured digital information over graphical data. With advancing digitalisation, there is a growing demand for building data to be logically and geometrically linked from different sources for a holistic view.

The national mapping agency swisstopo has therefore initiated the study "Official Building CH" to investigate the idea of a new product "Official Building CH" and to work out various implementation proposals. This paper summarises the most important work, findings and results of the study.

1.2 Objectives of the study

In the long term, the aim is to create a uniform, official data model for the digital image of Switzerland's buildings. This model (and data set) should meet the requirements of today and tomorrow, including interoperability with BIM data from digital planning, construction and operation.

Main objective of the study: Development and creation of a basis for the initialisation of a new, interdisciplinary data model "Official Building CH".

The following tasks were dealt with as part of the study:

- Investigate the need and potential of an "Official Building CH" product.
- Develop a proposal for the term "building".
- Develop a draft data model for "Official Buildings CH" (including a study of variants, taking into account existing national and international standards).
- Show further procedure (roadmap).

2 SITUATION ANALYSIS

2.1 Stakeholder assessment

Information and data on buildings are used by different disciplines in their daily work. Depending on the tasks and questions, the views of the building can be very different. Within the scope of a basic assessment, various stakeholders were identified who cover the following views of the building:

- Legal and normative view, best practices
- Spatial planning view including matters of conception and design
- View of statistics, insurance, energy, emergency services, economy
- View of the entire construction value chain:
  - Planning
  - Structural (construction and refurbishment)
  - Operational

The most important statements of the stakeholders with regards to a harmonised term "building" and a future data model "Official Building CH" can be summarised as follows:

- Building information is of major to very high importance for most of the respondents.
- Today, building data is used for a wide variety of purposes. With a uniform data model "Official Building CH" and a database based on it, further synergies are obvious (e.g. energy efficiency/CO2 reporting, Second Home requirements, "Smart City").
- There is great interest in a harmonised term "building".
- There is a strong to very strong interest in a standardisation of building information.
- In particular, the following requirements are demanded of an "Official Building CH":
- Uniform terms are to be used, considering the definitions from the RBD (building term) and the standards and norms defined by the Swiss Society of Engineers and Architects (SIA) on building spaces and volumes.
- The definitions must not contradict legal building terms or masses.
- Existing data, standards and processes are to be used, not a greenfield start.
- Differentiation to other structures is important.

2.2 Context analysis

2.2.1 Current situation of national building databases

The following three databases were included in the analysis and considerations of the study:

- CD: Data from multi-purpose cadastre (Cadastral Data)
- RBD: Federal Register of Buildings and Dwellings
- swissBUILDINGS^{3D}

These three databases are available throughout Switzerland and are provided by the public sector. Through the harmonisation of the RBD and CD, significant and valuable development steps have been and are being achieved for this information with regard to the completeness and congruence of the objects. The existing 3D dataset swissBUILDINGS^{3D} deviates from this object structure due to an alternative production approach.

swisstopo is currently investigating how the swissBUILDINGS^{3D} product can be further developed to match the RBD and CD structures in the future, so that it should be easy to link information via the common identificator.

2.2.2 International standards

Data models with a focus on building information have been developed and published by various organisations in the last 10 years. The investigated models LandInfra (formerly LandXML), CityGML, Industry Foundation Classes (IFC, from the BIM method) and Land Administration Domain Model (LADM) are used in various countries and were thus considered as a potential basis for a data model "Official Building CH". Interestingly, the buzzwords "smart city" and "digital twin" that have emerged in recent years are not yet explicitly linked to any data models.
Even though the analysed models contain information about buildings, the main contents and goals are very different. The following figure shows the international data models examined in the study with their respective focus very well.

Figure 1 Overview of relevant international building standards

The challenges arising from the different focus are shown in the following figure as an example of the comparison of the object "wall" in an IFC dataset (solid body) and a CityGML (wall defined as visible surfaces with an outside and inside, meaning 2 or more objects).

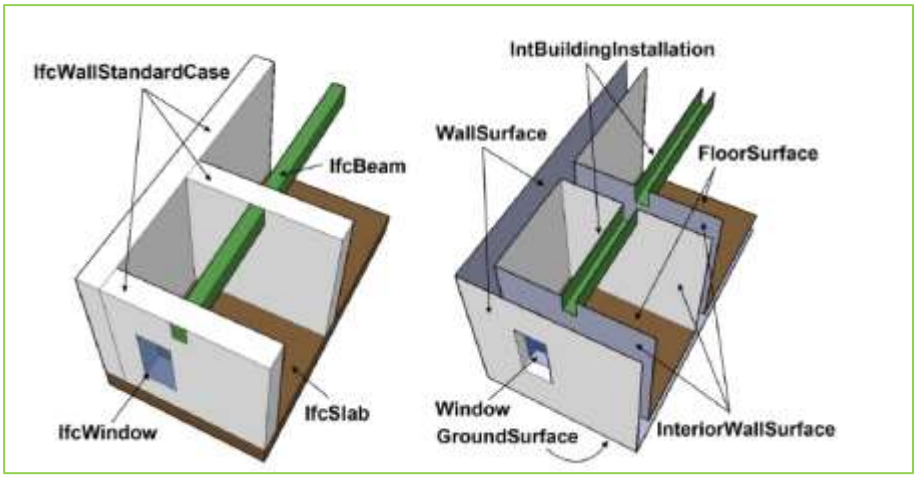


Figure 2 Different modelling of a wall in IFC and CityGML (Source: Nagel et. al. 2009)

It is not surprising that different approaches are being tested to transform data between models (especially between CityGML and IFC, as CityGML has the most extensive datasets today). However, various studies by Deng (2016), Gilbert (2020), Noardo (2019), Sun (2019) or Zadeh (2019) show that these transformations do not work sufficiently.

In addition to the challenges discussed regarding focus, the following two factors also play a significant role in the suitability of an international standard as the basis for the data model "Official Building CH":

- What are the main application purposes of a future "Official Building CH" data model?
- What is the availability of data? The costs for data collection and possible conversion should not be neglected.

2.2.3 National standards

In the context of the context analysis, various national standards were analysed with regard to their provisions for information on the geometric characteristics of a building.
The most important findings from the analysis of the national standards can be summarised as follows:

- SIA has different standards on geometric information about buildings and derived energetic consideration. A support of the indicators offers interesting options.
- SIA Instruction on Building Information Modelling (BIM) defines various terms in the context of BIM (understanding). These are to be taken into account.
- The eCH standard Object Management defines the meaning and semantics of object data (including buildings) as well as automated data exchange processes. These must be taken into account in the implementation.
- An adaptation of IFC to national conditions is not (yet) available in a suitable form.

3 DEFINITION OF THE TERM "BUILDING"

3.1 Definition of a *building*

In the stakeholder consultations, the currently used terms for "building" were compiled. In order not to add another new term, it is recommended to use the already existing, well-known and well-supported RBD building term according to Art. 2 in den Ordinance of RBD.

A *building* is a permanent structure with a roof, firmly attached to the ground, capable of accommodating persons and used for residential purposes or purposes of work, education, culture, sport or any other human activity;

a semi-detached, group and terraced house also counts as a building if it has its own access from the outside and if there is a vertical load-bearing partition wall between the buildings extending from the ground floor to the roof.

Consequences of this definition for the study:

- A *building object* in the " Official Buildings CH" database corresponds in principle to a building object in the RBD.
- The object structures and granularity of the official building model are based on the regulations of the RBD and the CD.
- A building object exists throughout its entire life cycle in the "Official Building CH" dataset. An object is never deleted, the status is changed.

3.2 Positioning of the building model in the overarching theme of constructions

With the emergence of digital construction and the development of the BIM method, in the first years almost exclusively "buildings" were designed according to the new paradigm. Increasingly, however, the term "digital civil works model" is being used instead of "digital building model". The SIA Brochure 2051 BIM of 2017 introduces the term "digital civil works models" (building as a generic term for all buildings and civil engineering structures). The topic of "buildings" must thus be thought of in the larger context of artificial structures. This helps to understand what is a building and what is not. Furthermore, structures of different types and usages are combined with each other. A definition of a building structure will therefore quickly include other types of structures. The following figure shows the classification of the building in the scheme civil works:

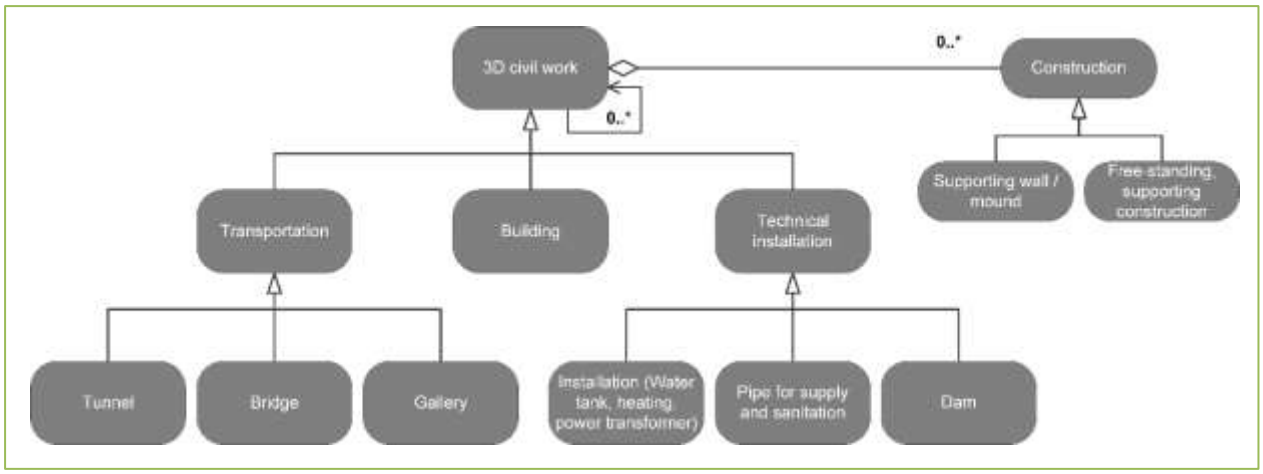


Figure 3 Scheme of the 3D civil work model

4 DRAFT "OFFICIAL BUILDING CH" DATA MODEL

4.1 Variants

Based on the environment analysis and the requirements defined in chapter 3, three possible approaches for modelling were identified and then compared in a study of variants:

1. 1:1 takeover: Use the international standard 1:1
2. adaptation: extend and adapt the international standard
3. "Neutral model": Design own neutral model
   - "Own": Swiss model
   - "Neutral": Application-independent, not directly linked to international standards.
   - Boundary constraint: enable bi-directional exchange with IFC and CityGML.

The result of the study of variants can be summarised as follows:

- Variant 1 "1:1 takeover" - Do not pursue further.
  Due to the objectives for the database and the requirements for the data model, this variant will not be pursued further.
- Variant 2 "Adaptation" - Will not be further modelled
  This variant offers interesting perspectives, but will not be modelled further for the moment. The conceptual possibilities of adapting an international standard to a (Swiss) profile allow that a data model elaborated for variant 3 can also be tested as a profile of an international standard in a later project phase. The main disadvantage of using IFC as a basis is that its implementation has not yet been hardened, which leads to significant problems in data exchange.
- Variant 3 "Neutral model" - Best target fulfilment
  This variant has the best target fulfilment, even if the effort for a qualitatively good exchange from and to IFC or CityGML is not negligible. Various studies show possible solutions for this.

Based on the objectives of the data stock and the requirements for a good usable data model, variant 3 of an independent, neutral model is preferred. A conceptual model structure is therefore designed for this variant.

4.2 Proposal for the "Official Building CH" data model

For the preferred variant, a conceptual data model was designed at the level of a class diagram (see Figure 4). Suggestions for the geometric modelling, some notes on the appropriate capture guidelines and suggestions for data updating complete the specifications of the data structure.

The proposal for the data model "Official Building CH" comprises the following classes:

- Class "Roof
- Class "Slab
- Class "Facade
- Classes "Construction" and " Transportation".

The class diagram can be extended via standardised classes or private classes. Standardised extensions are used, for example, for the 3D documentation of the condominium. The exploded drawing (Figure 6) visualises the classes provided in the data model on an illustrative building.

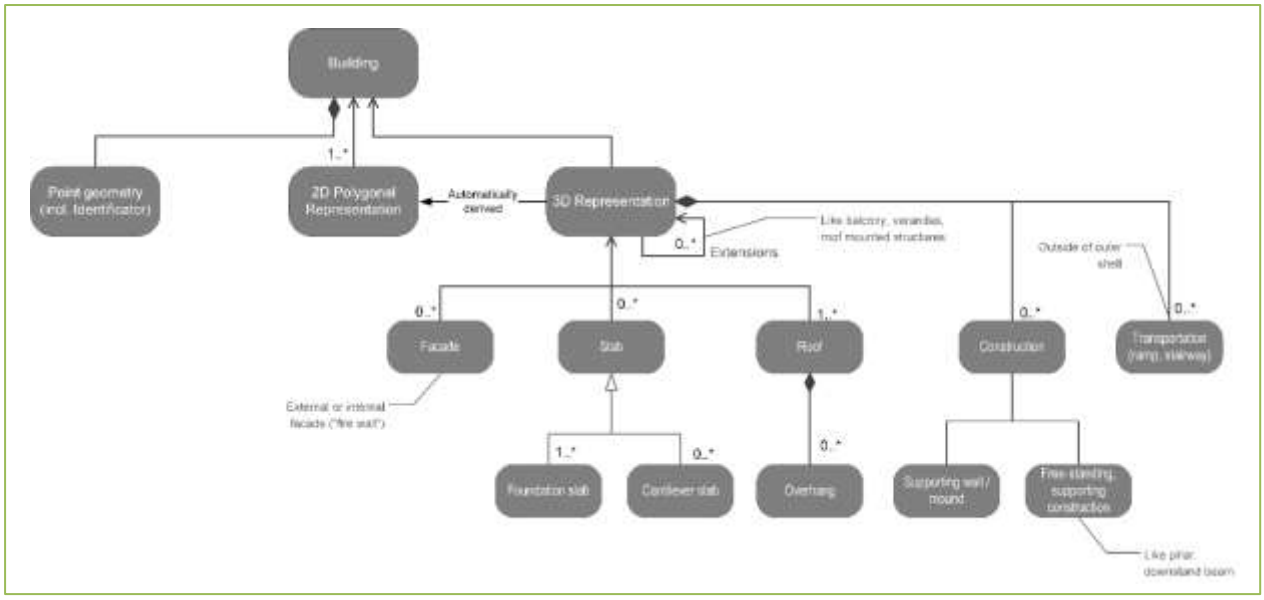
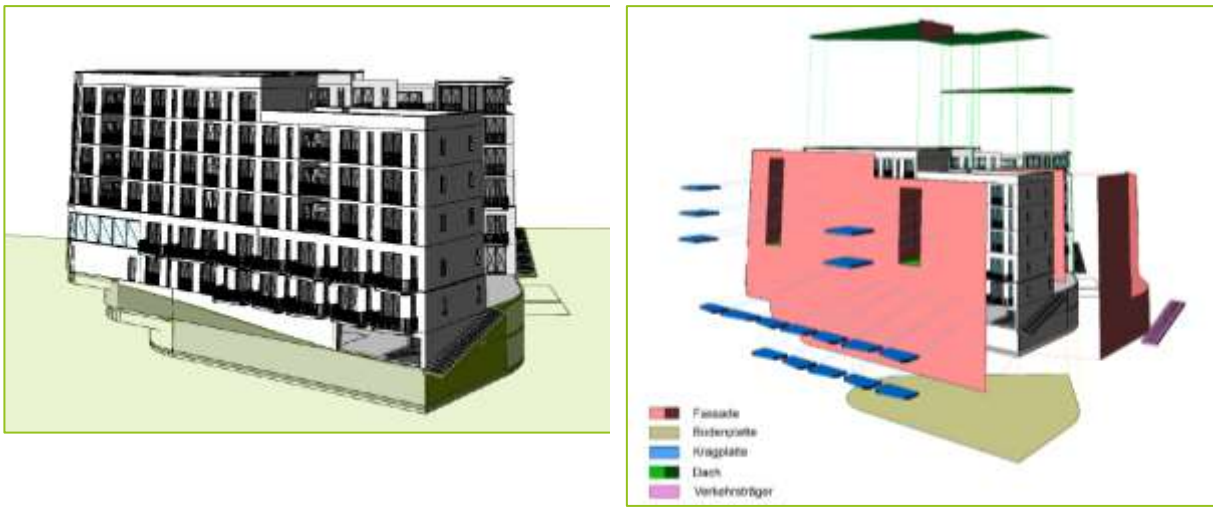


Figure 4 Data model "Official building CH" - class diagram with details of the 3D structure



a) Data source for exploded view, green areas represent simplified terrain

b) Exploded representation of the data model "Official Building CH

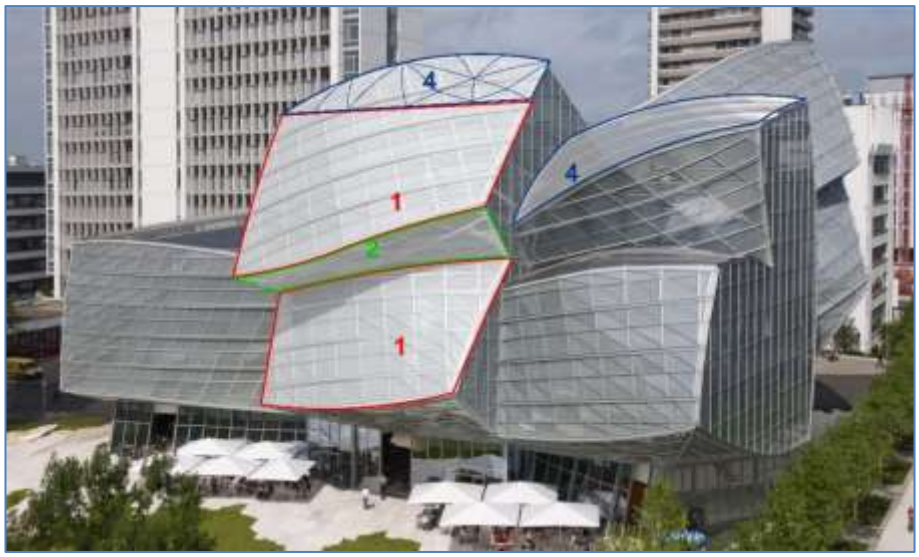
Figure 5 Exploded view (data source: SIA documentation D 0270)

The data model was checked for plausibility using various real buildings. The following figures show the individual elements provided in the data model. Furthermore, it was checked whether the recently published data model for the digital documentation of condominium ownership corresponds to the proposed data structures.

Figure 6 Solution approach for the implementation of a larger site in Zurich in the new data model

Focus: General validation of the classes of the data model

Legend
1. facades with offset
2. roof (-terrace)
3. cantilever
4. roof structure (habitable)
5. roof construction
6. installation (chimney)
7. construction (joist)



Focus:
- Roof-wall transition,
- triangular mesh for curved surfaces

Legend
1. facades
2. slab (cantilever slab)
3. (no construction)
4. roof (incl. triangular mesh indicated)

Figure 7 Solution approach for the "Gehry Buildings" in the new data model

Focus:
- Roof-wall transition "Where snow remains, is roof"

Figure 8 Shell construction of the stone church in Cazis (source: graubuenden.ch)

5 CONCLUSION AND OUTLOOK

The designed data model was validated against a wide range of complex buildings. It has been shown that the data structures cover all components of the building that are relevant from the point of view of a national database. The data model can be extended specifically to also document condominium ownership in accordance with the national recommendation. The use of basic structures from IFC respectively CityGML makes it possible to transfer the existing swissBUILDINGS3D database into the new structure as well as to integrate new data in IFC format.

Based on the positive feedback from current and potential users of a "Official Buildings CH" repository, this work should be continued. According to statements by some organisations, the timing is ideal, as many of them will be digitising their processes in the coming years. If they can already align themselves with a holistic, harmonised, official database, this will be very welcome. The interest is also reflected in the fact that various respondents would like to be actively involved in the development. The upcoming changes in the CD could also be used for joint further development.
The great interest in the study has shown that building information is already important for many different actors today, but will become increasingly important in the future. Although the topic of "digitalisation" is abstract, it becomes very real for many organisations in their everyday work due to the demand for efficient work processes and optimised use of resources. This is also reflected in the rapidly growing use of the BIM method. As a result, structures that have been in place for a long time will no longer simply be accepted, but will probably be questioned more and more frequently in the future (e.g. the insurance number for building insurance, which is to be replaced by the RBD).
A harmonised, official repository offers users a significant advantage over data from private providers due to its greater reliability and integrability with other data and business processes. The recommended variant and the developed data model take all these developments and requirements into account.

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BIOGRAPHICAL NOTES

Dr. Jürg H. Lüthy is member of the Management Board at Acht Grad Ost AG, one of the largest geomatics companies in Switzerland. He obtained a master's degree in 1996 from Federal Institute of Technology Zurich (Switzerland) in Rural Engineering and Survey. From the same institution he holds a PhD (2007). He has a wide experience in spatial data

management, transition from paper maps to data centric systems and the operation of Spatial Data Infrastructures. His current focus lies in the provision of holistic information management through data linking, both spatial and numerical data. He uses innovative approaches to develop solutions from government data for customer-oriented applications for private and public organisations. He is the Swiss delegate to FIG Commission 3. Since 2016 he is president of SLM Swiss Landmanagement Foundation.

Carla Thomas is a member of the Management Board at Acht Grad Ost AG, one of the largest geomatics companies in Switzerland. In 1997, she obtained her master's degree in Rural Engineering from the Swiss Federal Institute of Technology in Zurich (ETH, Switzerland). After various positions in national and international working environment, she now works as a project manager and consultant for geoinformatics and infrastructure at Acht Grad Ost AG in Schlieren.
“From paper to the app” - since graduating, Carla Thoma has repeatedly been confronted with the paradigm shift towards data-centric use in projects. Together with her clients, she seeks for the "right questions" to identify and analyse the information needs. By doing so she’s translating between the various specialists with the aim of providing the client with adapted data and information as well as platforms for efficient and optimal use. In her field of work, the focus lies on people and organisations with their tasks and processes.
Carla Thoma is a member of the BIM Standards Commission of the Swiss Society of Engineers and Architects (SIA).

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