

# APPLICABILITY OF SAF IN PRACTICE

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## ABSTRAKT

Formát SAF (Structural Analysis Format) je souborový formát, který umožňuje výměnu dat mezi různými programy a zlepšuje spolupráci v oblasti architektury, inženýrství a stavebnictví. Tento článek popisuje dva pracovní postupy, které využívají SAF jako formát pro výměnu dat mezi CAD a CAE programy. První pracovní postup představuje SCIA AutoConverter, cloudový software, který automatizuje proces převodu konstrukčních modelů (IFC) na validní analytické modely (SAF). Druhý pracovní postup popisuje použití SAF při výměně dat mezi Archicadem a CAE softwarem. Dále článek popisuje využití SAF při propojování různých softwarových aplikací v oblasti statiky, jako je propojení mezi SCIA Engineer a IDEA StatiCa nebo Frilo MWX+, tedy propojení mezi CAE a CAE. Všechny pracovní postupy jsou vyhodnoceny, jsou identifikovány přínosy a možnosti zlepšení. Celkově lze říci, že SAF je slibný formát pro výměnu dat v odvětví CAE se zaměřením na obor statické analýzy.

## KLÍČOVÁ SLOVA

SAF • BIM • Automation • Statický Model Konstrukce • Výměna Dat

## ABSTRACT

Structural Analysis Format (SAF) is a file format that enables data exchange between different software programs, improving collaboration in the architecture, engineering, and construction industry. This article highlights two workflows that use SAF as an exchange format between CAD and CAE software. The first workflow involves the SCIA AutoConverter, a cloud-based software that automates the process of converting structural models (IFC) to valid analysis models (SAF). The second workflow describes the use of SAF in data exchange between Archicad and CAE software. Furthermore, the article highlights the use of SAF in linking various software applications in the structural engineering field, such as link between SCIA Engineer and IDEA StatiCa or Frilo MWX+. All workflows are evaluated, benefits and improvement possibilities are identified. Overall, SAF is promising format in data exchange in CAE industry with focus on structural analysis discipline.

## KEYWORDS

SAF • BIM • Automation • Structural Analysis Model • Data Exchange

## 1. INTRODUCTION

The Structural Analysis Format (SAF) is a file format used for exchanging structural analysis models and related data between different software applications. Invented by SCIA, a company of the Nemetschek Group, SAF has become increasingly popular in the architecture, engineering, and construction (AEC) industry due to its open-source nature and ability to seamlessly transfer data between different software programs. SAF allows for improved collaboration and reduces errors in the design process by enabling the exchange of data such as geometry, material properties, loads, and boundary conditions between different structural analysis software applications. In this article, we will explore the key features and benefits of SAF, as well as its limitations and best practices for working with SAF files in different software environments. By understanding the strengths and weaknesses of SAF, architects and engineers can optimize their workflows and create more efficient and effective building designs. NEMETSCHKEK GROUP (n.d.)

## 2. SAF USAGE IN PRAXIS (CAD TO CAE)

Since SAF was introduced in 2019, its coverage of structural analysis objects (capability to transfer them) has increased. Better object coverage, improvements in documentation, object extensions and fixes that are continuously being added to SAF definition combined together lead to the increased usage of SAF format in praxis. In this chapter, I would like to describe and evaluate more in detail selected workflows where SAF, an open-source format for structural analysis models is used in data exchange between CAD and CAE software. NEMETSCHKEK GROUP (n.d.)

### 2.1. SAF in SCIA AutoConverter

SCIA AutoConverter is a cloud-based software developed by SCIA, a company of the Nemetschek Group. Its purpose is to automate the process of converting structural models in IFC format developed and maintained by BuildingSmart as inputs, to the valid analysis models in SAF format as an output. With SCIA AutoConverter, structural engineers can import structural models from a variety of CAD software, including Tekla, Revit, Allplan, Archicad, AdvanceSteel and more in commonly used open BIM (Building Information Modeling) format IFC (IFC2x3 or IFC4). This streamlines the process of transferring models between CAD software to different CAE software, which helps to reduce time spent by remodelling and reduce the risk of errors. SCIA AutoConverter is available for all students and teachers for free. (BuildingSmart n.d.) (SCIA n.d.e)

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### Workflow description:

1. Select model: Here the user can select one structural model intended for conversion.
2. Clean model: Here the user should remove non-load-bearing elements from a structure.
3. Recognizer settings: Here can be adjusted conversion rules of structural entities to analysis entities. Default settings is based on IFCtypes, but can be overwritten with user input.
4. Recognize: Here the actual conversion is done and first instance of analysis model is created.
5. Alignment setting: Here user can adjust position of system lines, system planes and define so called master planes, that play significant role in final step of conversion procedure.
6. Alignment: Last step where analysis first instance analysis entities are connected together in the final analysis model. The connection of elements is done based on settings that can user adjust.

On the output, there is SAF file (Figure 1) containing complete data about geometry, cross-section and materials. SAF file can be exported in various versions, which provides better compatibility with analysis software supporting SAF format. (SCIA n.d.d)

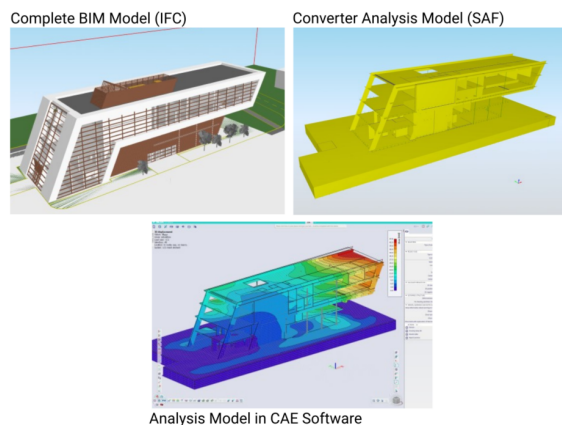


Figure 1: SAF model as transfer format between SCIA AutoConverter and CAE software (.jpg file).

### Evaluation of workflow:

- + Process of conversion is straightforward
- + Support of widely used IFC models provides compatibility with vast majority of CAD software
- + SCIA AutoConverter provides options for storing revision of both, analysis and structural model in one cloud project
- Users need yet another software together with CAD and CAE programs
- Workflows where analysis models are created before structural cannot benefit from this tool

## 2.2. From Archicad to CAE software using SAF

Archicad, by Graphisoft, is a robust CAD software program utilized in the AEC industry to design and create highly detailed 3D

models of buildings, structures, and interiors. The software's sophisticated BIM capabilities allow users to incorporate various design and construction data into a single model, enhancing communication and collaboration among project stakeholders. Archicad provides accurate digital representations of buildings, complete with detailed plans, sections, elevations, and schedules.

Archicad provides architects and engineers with the option to generate analysis models. Structural Analysis Model (SAM) is generated for structural elements such as columns, beams, walls, slabs, and roofs (Load Bearing Elements). The SAM is a simplified model that includes only the essential information necessary for structural analysis and design, such as geometry, material properties, and load data. The SAM can be exported to SAF format, to be used in structural analysis software for further analysis and design. Graphisoft (n.d.a)

SAM generation follows defined rules in Archicad. Rules can be found under the "Structural Analytical Model Generation Rules". These rules can be customized by the user and determine how the connection between elements is established, such as extending a column to the plane of a slab above or trimming a beam in a steel frame corner. The rules also cover other aspects, like ignoring small openings in walls and slabs. It is recommended to start with the default rules and make adjustments as needed. (Figure 2) Graphisoft (n.d.a)

### Exporting of SAM to SAF format:

1. Go to File > Interoperability > Structural Analysis Format (SAF) to open the SAF Translator dialog box.
2. In the SAF Translator dialog box, select the SAF version you want to use for the export and set any additional export options as needed.
3. Click the Save As button to save the SAF file to your desired location.
4. In the Save As dialog box, enter a name for the SAF file and choose a location to save it.
5. Click the Save button to export the SAF file from Archicad.

SAF translators play a critical role in facilitating the effective transfer of structural data between Archicad and CAE software like SCIA Engineer, Dlubal RFEM, Risa 3D, AxisVM, FEM-Design and others. One of the key functions of SAF translators is to enable the transfer of material properties and cross-section data from Archicad to the analysis software. Archicad offers SAF translators that are available online on their website and come with predefined settings for selected analysis software. These settings make it easy to set up the transfer of data between Archicad and analysis software, reducing the need for manual data entry and minimizing the potential for errors. Graphisoft (n.d.b)

### Evaluation of workflow:

- + SAM is generated automatically based on adjustable settings
- + SAF translators ensure data compatibility with CAE software
- + Archicad provides an option for updating structural models based on changes done CAE software (revision compare using SAF)
- Analysis model is created in CAD software and therefore there are requirements for structural engineering knowledge
- For complex geometries SAM can't be created - curved walls for example

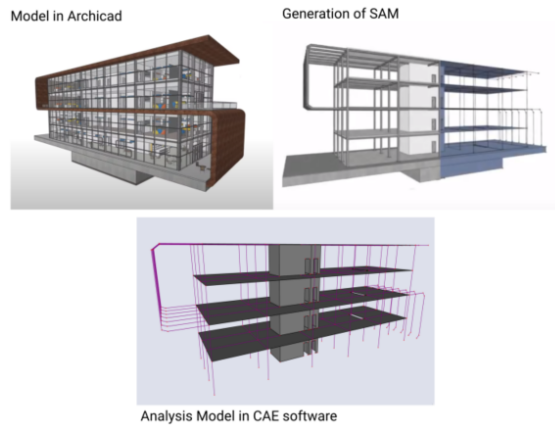


Figure 2: SAF model as transfer format between Archicad and CAE software (.jpg file).

### 3. SAF LINKS WITH SCIA ENGINEER (CAE TO CAE)

In this chapter, let me focus on two workflows that are using SAF as an exchange format between two CAE software. In comparison to the previous chapter, now we stay in the structural engineering domain.

#### 3.1. SAF in link to IDEA StatiCa

IDEA StatiCa is software for structural engineers to analyze and optimize designs of steel, concrete, timber, and composite structures. In this part, let's focus more on IDEA StatiCa Connection (specialized 3D software for design and check of steel connections) and IDEA StatiCa Member (specialized software for complex analysis of whole steel members, including stability and buckling behaviour, supporting also geometrically and materially non-linear analysis with imperfections). IDEA (n.d.)

In this workflow, SAF is used as a transfer format between SCIA Engineer and IDEA StatiCa Checkbot. On-demand, once engineer clicks on "Connection" or "Member" icon in Checkbot window, the SAF file is created in real-time from a selection of elements in the SCIA Engineer 3D scene. IDEA is informed about the event and reads the file including internal forces and loads and via Checkbot are 1D members distributed to specialized applications. SAF was selected as an exchange format because it is an open source, which means once the infrastructure is set in one software, it can be reused for other BIM links. (Figure 3) SCIA (n.d.b)

##### Workflow description:

1. In SCIA Engineer, run command IDEA StatiCa
2. IDEA Checkbot (management app) opens
3. Make a selection of elements in SCIA Engineer intended to be used in IDEA Connection or IDEA Member
4. Click on "Connection" or "Member" icon to initiate the import
5. Imported elements are visible in Checkbot from where they can be distributed to specialized applications

##### Evaluation of workflow:

- + Intuitive and easy-to-use live BIM link
- + All steel connections and members can be managed in IDEA Checkbot

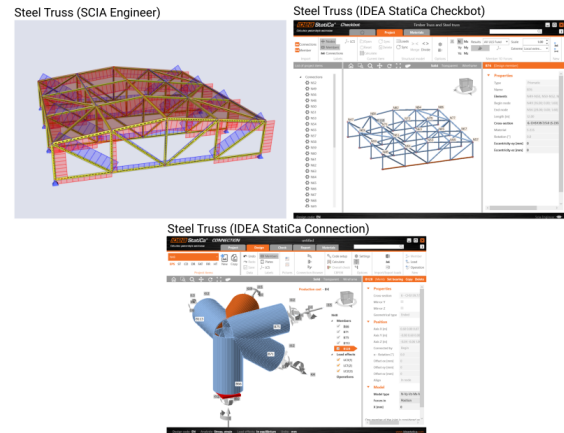


Figure 3: SAF model as transfer format between SCIA Engineer and IDEA StatiCa Checkbot (.jpg file).

- + Data in IDEA check bot can be updated in case changes were done in model in SCIA Engineer
- Only results from the linear analysis are currently transferred to IDEA Checkbot
- Export of data takes dozens of seconds in some cases

#### 3.2. SAF in link to Frilo MWH+

Frilo MWX+ is a structural analysis software suitable for verifying individual walls and structural systems consisting of basement walls, intermediate storey walls, and top storey walls. The software considers the border conditions determined by the connected components such as bending stiffness of walls above and underneath the considered wall, and supporting conditions of floor slabs on the opposite side of the wall. In the context of SCIA Engineer software, we can label Frilo MWX+ models as submodels of SCIA Engineer complete 3D analysis model.

##### Workflow description:

1. In SCIA Engineer, place an integration strip on the masonry wall
2. In SCIA Engineer, call the command "Frilo masonry check"
3. In SCIA Engineer property bar, click on "Export to Frilo masonry"
4. In SCIA Engineer, select the integration strip intended to be exported
5. Frilo MWX+ is being run with submodel defined by integration strip

Once the command "Export to Frilo masonry" is called, SAF submodel is created in the background for Frilo MWX+ application. Submodel for Frilo MWX+ includes neighbouring slabs, walls above and below and the masonry strip width is equal to the width of the integration strip. The spans of neighbouring slabs have to be adjusted manually in Frilo app including constraints types at the ends of each span. Together with geometry and materials, there are exported loads and results on 2D members' edges. (Figure 4) SCIA (n.d.a)

##### Evaluation of workflow:

- + Intuitive and easy-to-use BIM link
- + Submodel is created automatically in an overall good quality

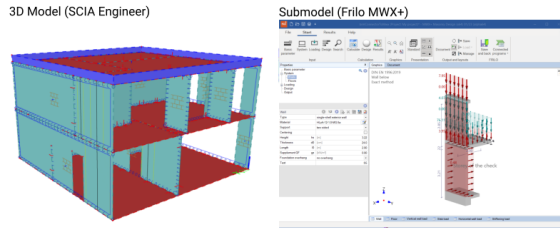


Figure 4: SAF model as transfer format between SCIA Engineer and Frilo MWX+ (.jpg file).

- + Model is easy to review in Frilo MWX+
- Surface Free Loads are exported as Surface Loads which can end up with an unnecessary too many loads object that has to be removed manually from the Frilo model
- Export of data takes dozens of seconds in some cases

#### 4. SAF EXAMPLE IN PRE-DESIGN STATE

SAF analysis model is clearly defined excel file. The analysis model can be easily created and edited in a table editor. The valid model needs to meet only rules that are defined in the SAF guide. A structural engineer can create excel files with SAF structure using macros in Excel or small apps that can generate parametrical geometry of the structure. Topology can be easily changed, together with all SAF attributes and objects. With the parametrical generation of a file, it is easy to create multiple options of load-bearing structure layouts and evaluate the results of the analysis in CAE software without the need to spend time manually modelling every option.

SAF is part also a more advanced solution requiring scripting knowledge. For example, users can connect applications to SCIA Engineer and read, adjust and write back SAF data in real time. Also, currently is under development new version of the Koala plugin to Rhino Grasshopper, which will create an SAF file out of Rhino geometry. SCIA (n.d.c) SCIA (n.d.f)

#### 5. CONCLUSIONS

Structural Analysis Format (SAF) is an open-source file format that has become increasingly popular in the architecture, engineering, and construction industry. SAF enables the exchange of data between different programs, improving collaboration and reducing errors in the design process. The article describes two workflows that use SAF as an exchange format CAD and CAE software. SCIA AutoConverter, a cloud-based software that automates the process of converting structural models to valid analysis models in SAF format and the use of SAF in data exchange between Archicad and CAE software together with build-in generation of the structural analysis model. While the process of conversion in SCIA AutoConverter is straightforward and steered by a structural engineer, the need for additional software licenses and the fact that is not covering workflow where analysis model is created before structural model are some of the limitations. Archicad also provides good service for analysis model creation with SAF translators, on the other hand, it requires basic structural engineering knowledge and complex shapes are not supported in SAM generation yet. Both workflows have time-saving potential because the remodelling part in CAE software is significantly reduced.

Then two workflows between SCIA Engineer and IDEA StatiCa Checkbot together with Frilo MWX+. SAF format has proven to be a useful tool in linking various software applications in the structural engineering field, such as IDEA StatiCa and Frilo MWX+. The intuitive and easy-to-use BIM links have allowed for the seamless transfer of data between the software applications, allowing for efficient design and check of steel connections, members, and masonry walls. While there are some limitations to the current implementation of the SAF format, such as the transfer of only linear analysis results and longer export times for big data, the potential benefits of the SAF format and its ability to be reused for other BIM links make it a promising tool for the future of structural engineering.

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