Use Case

BCF & Issue management from Building Owners and Sustainability Consultants Perspective

BCF & Issue management from Building Owners and Sustainability Consultants Perspective – Asset management/owners and their issues documenting building airtightness & building retrofits

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GUID:	1d0806ff-af82-4ccf-9643-f098576bd46a
Version:	0.1
Published on:	2022-10-17
Last change:	2022-10-17
Life Cycle Stage:	ISO 22263
Maturity level:	Outlook

Use Case

Management Summary

- BCF can be used for Operation & Maintainance!
- Issue Management, with the help of BCF, could create additional added value for the building owner and sustainability consultants!
- Having a geometrical digital (3D) representation of the building asset will facilitate the understanding and navigation of the Issues (Location, Position, related Elements etc.)!
- BCF could be used for other use cases in operation phases...
    - Based on the performed expert analyses and inspections, BCF could be successfully implemented for Documentation Purposes (Building Airtightness Testings, Building Handover, Building Commission (MEP), Inventarisation and many more purposes...)

Use Case Definition

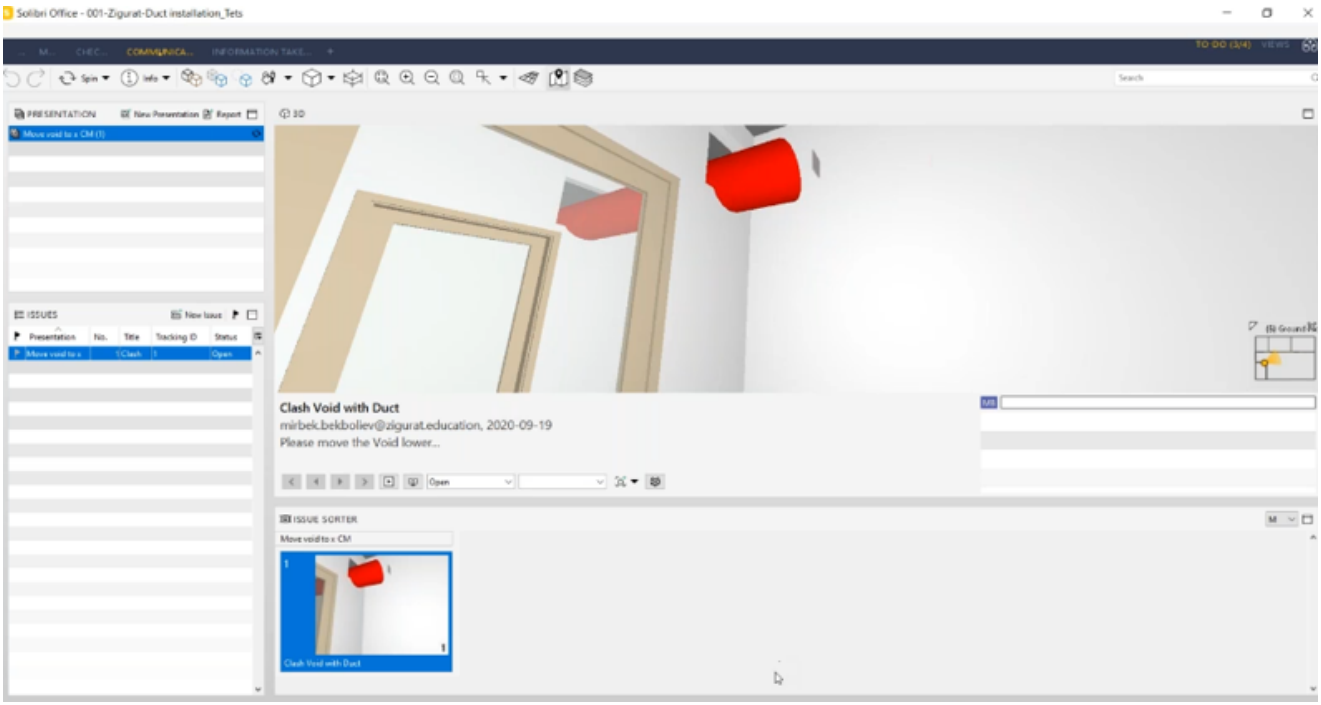
The **BIM Collaboration Format (BCF)** is a buildingSMART Standard and defines an interface for exchanging information between BIM software systems. For example, errors within the building models can be communicated for Quality Control and Quality Assurance purposes like Collisions (Soft & Hard or Time Clashes) or Modeling.

The exchanged information can be linked to building parts within the building model and consists of essentially two components:

- Subject: Issue Description – Name, Status, Comments, ...
- Viewpoint(s): Point at the problem - camera position, visible and selected components, sectional planes

How BCF is being used in the industry so far?

BCF is mainly used in the Design Phases for QC/QA Purposes of the BIM Models and very rarely in Construction or Operation Phases. Following is a classical Example of an Issue when an opening and Duct are not matching as well as not sealed properly. In addition, it is also used for communication purposes.



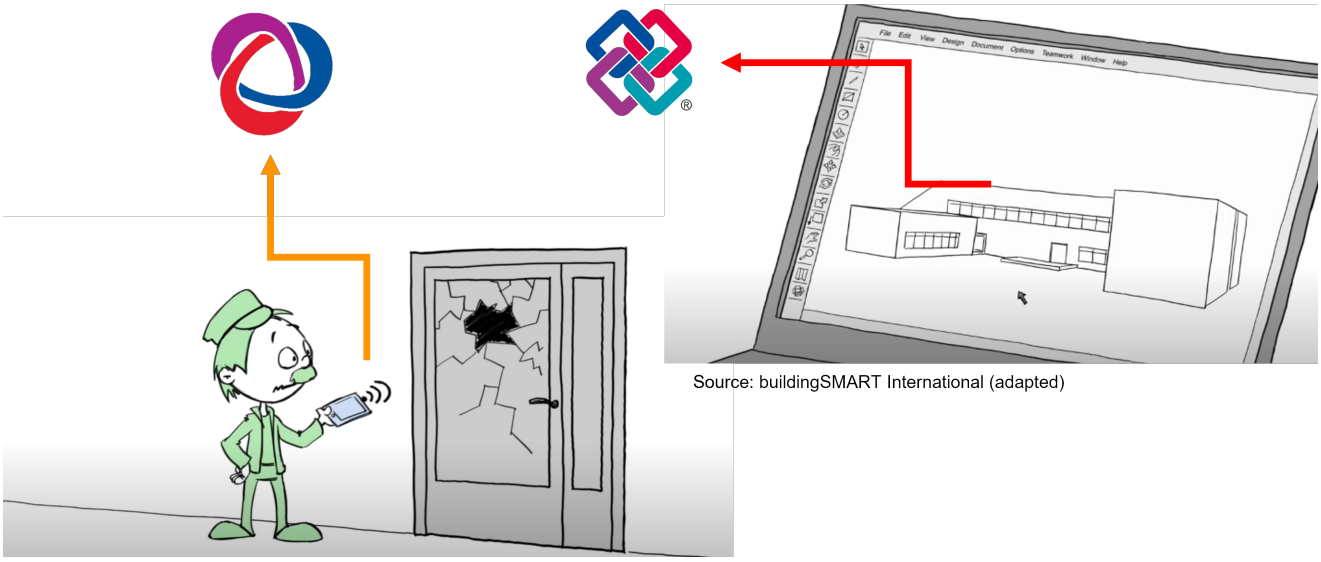
Example of a Hard Clash (Source: Mirbek Bekboliev, 2021)

Yet a general misconception is that the BCF is mainly used for "Clash Detection during the planning stages"...

What about Asset Management (O&M Phase) regarding BCF?

At the O&M Phases, a BCF could potentially help solve various issues regarding capturing dynamic changes at the building.

The idea is to have an As-built Model, which is expected to reflect the latest building condition before the handover. Further Issue Management Platform would take over the role of Documentation of all dynamic changes related to that model (repair, maintenance, conditions etc.), which could be communicated and documented with the help of BCF and Issue Management. Here is an Illustration of a proposed solution, which is an Inspiration from “What openBIM does for you?” by buildingSMART International / buildingSMART Norway -> https://www.youtube.com/watch?v=KppDDS3KnnM



Adapted Illustration for BCF and IFC (Source: buildingSMART International)

Localisation of Issues in a Building Model

Issue Management and Issue Resolution Process with 6 SIGMA (Source: https://www.whatissixsigma.net/project-issue-management-and-issue-resolution-process)

- What added value has BCF for Building Owners (e.g. Real Estate / Portfolio Managers) vs Existing Issue Management Systems??

    - Besides the Issue itself, the location of the Issue!
      Model-Based... (communication, FM, Q&M etc.)
- Why is the localisation of Issues important for building owners?
    - The qualification of the Issue Author (Sender) / Content Quality
- Does the localisation of issues have a potential budget saving in O&M?
    - Could the issue be resolved remotely?
    - Number of Travels
    - Judgement of Resources Needed (Misunderstanding of the Issue etc.)
- What are the challenges to locating an issue today?
    - The Accuracy of internal navigation technologies
    - Internal GPS System is costly for the intended purpose

Capturing Real Data from Site - Digitalisation of existing Asset

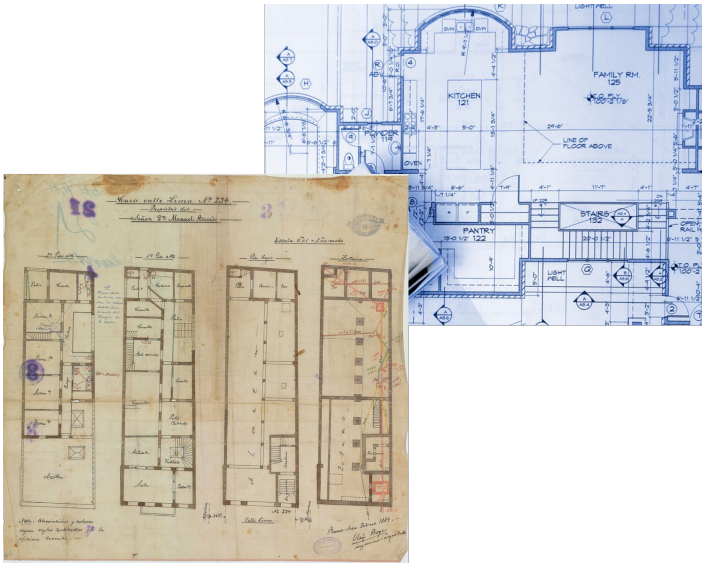
Case 1 when no drawings exist

- Laser Scanning
- Photogeometry
- Folding Rule

Source:?

Case 2 when drawings exist

- But only as Paper / PDF or best case DWG



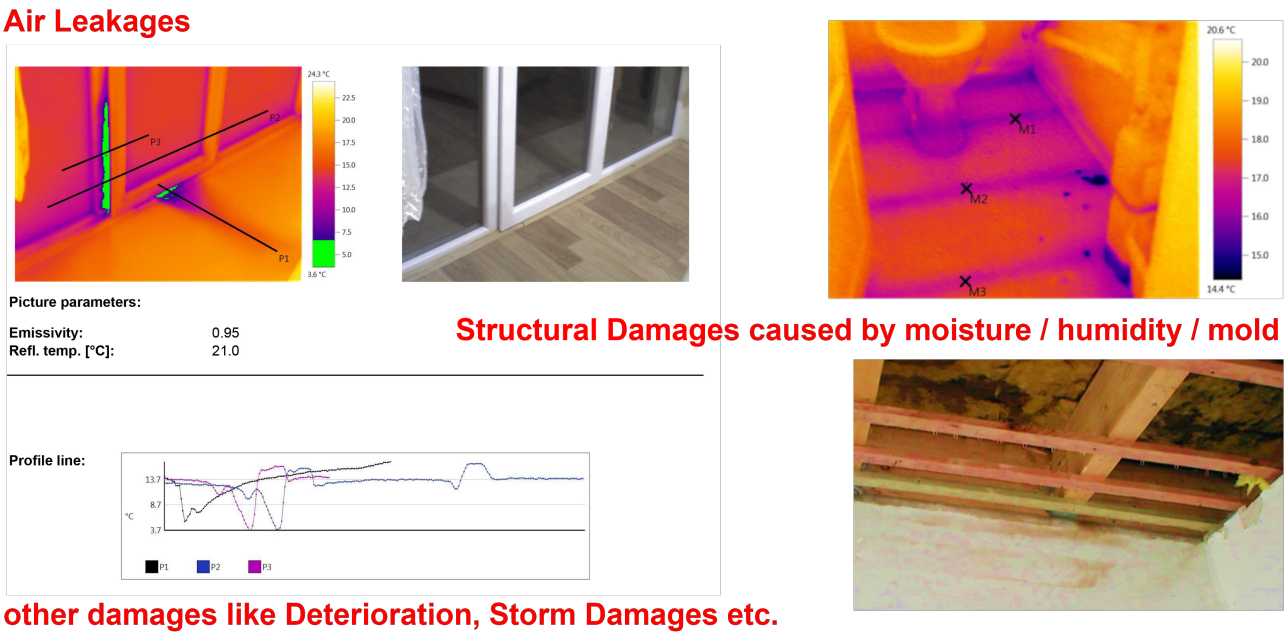
Source:?

Case 3, when the Model exists

- As-built
- Laser Scanning (Optional for Precision)

Typical Problems in Building Envelopes

During the construction, assembly and also operation phases, an onsite QC/QA could be performed with various tools like Blower Door Test and Infrared Thermal Imaging...in most of the use cases, potential issues/failures would be photographed and documented on paper or on a printed layout. Thus a big challenge would occur to an asset owner, sustainability consultant and related disciplines to locate them at a later stage.

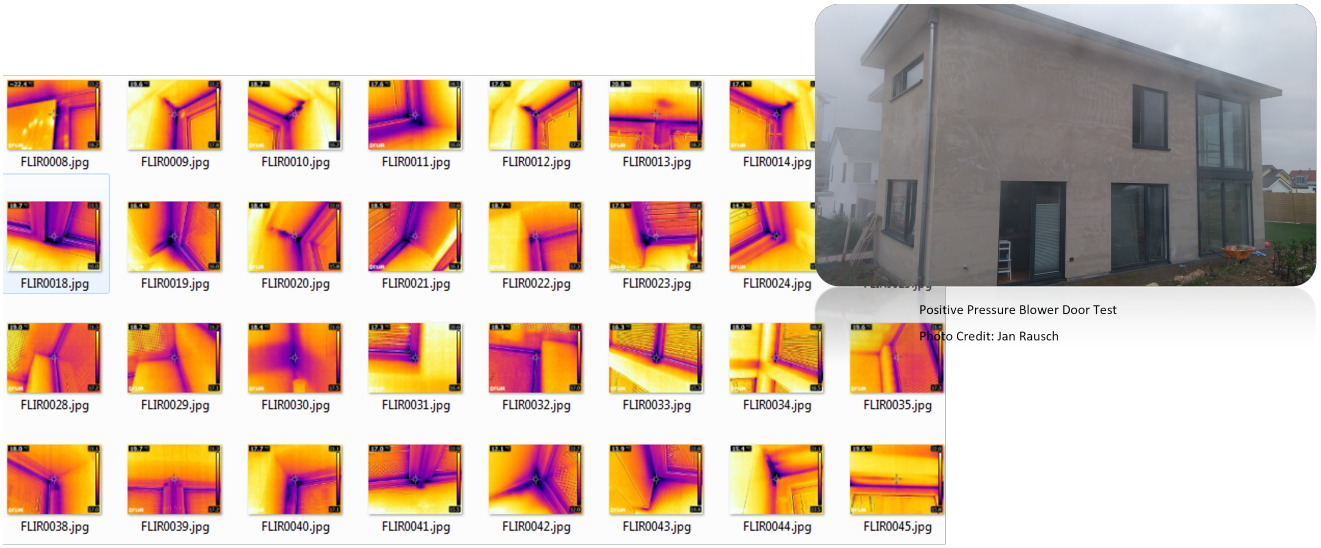


Typical Building Envelope Issues (Source: Mirbek Bekboliev, 2015).

The challenge of Locating the Issue (BCF) in the Small & Medium Assets

It would not make much effort to locate those issues on a small or medium-scale facility (Building); however, precise location and its current status are vital for the proper operation of the facility.

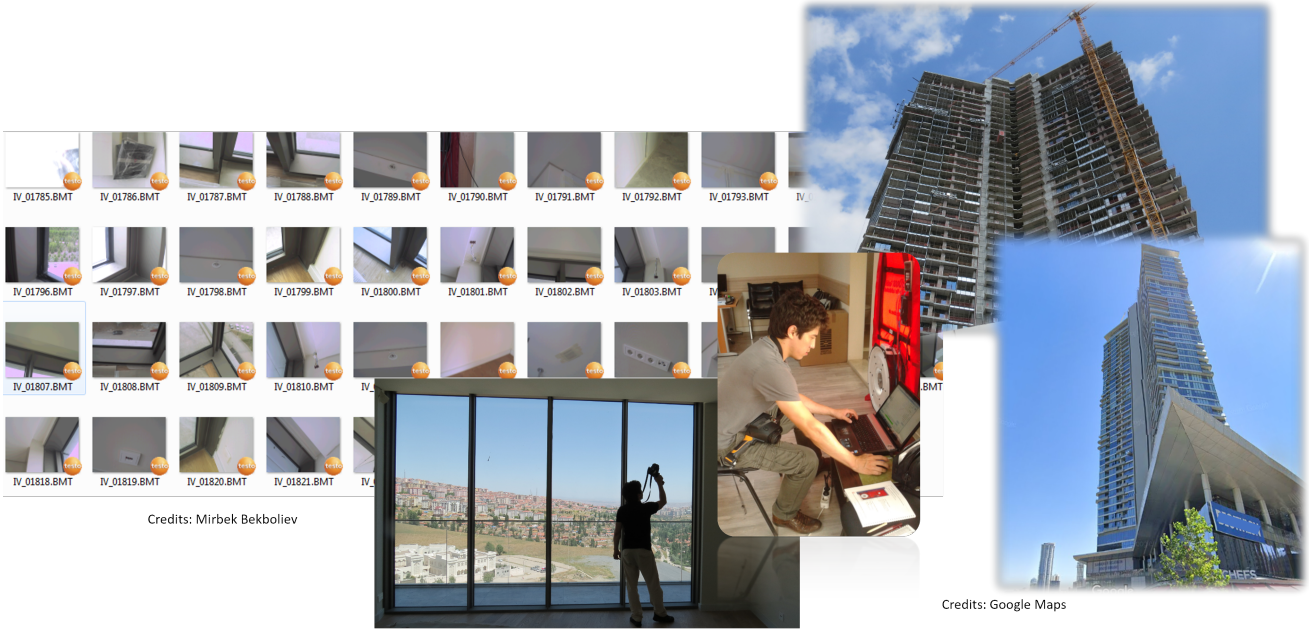
The usual practice is a manual entry of the Location, Storey, Room / Space ID / Space Name / Description etc.



Example for an Airtightness assessment of the building envelope of a Single Family House (Source: Mirbek Bekboliev, 2021)

The challenge of Locating the Issue (BCF) in the Large Asset

The more significant challenge occurs by providing a precise location of related building issues in a large-scale building. Like in a small-scale building, a manual entry of the location, Storey, Room / Space ID / Space Name / Description etc., would be performed on paper, yet a large number of storeys, areas and lack of Issue Management would potentially cause lost of information, and as a result, vital steps toward the elimination of those issues may be skipped.



Credits: Mirbek Bekboliev

Credits: Google Maps

Example for an Airtightness assessment of the building envelope of a Multi Family Residential Block (Source: Mirbek Bekboliev, 2015)

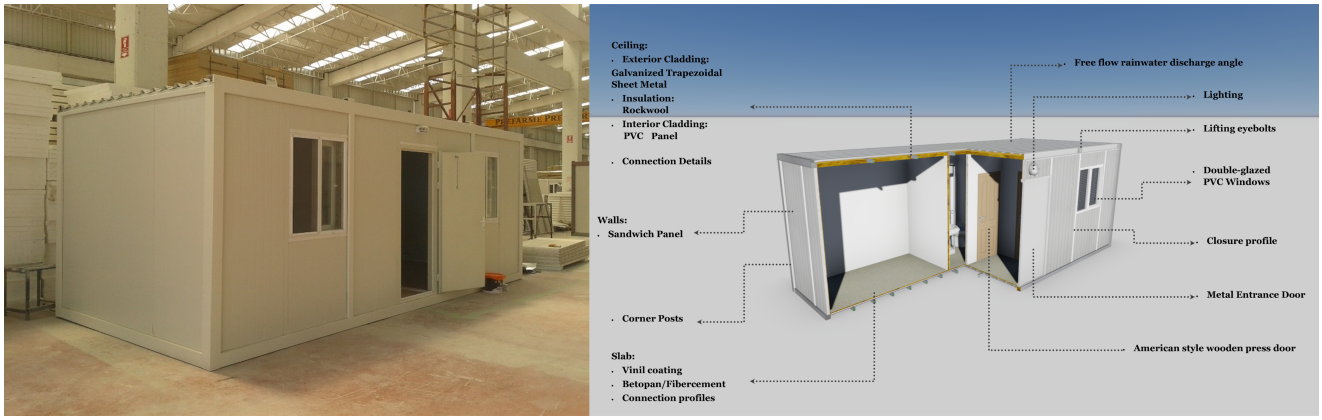
Issues after Handover (Best Cases with IFC Model)

Factory Assembly before Shippment

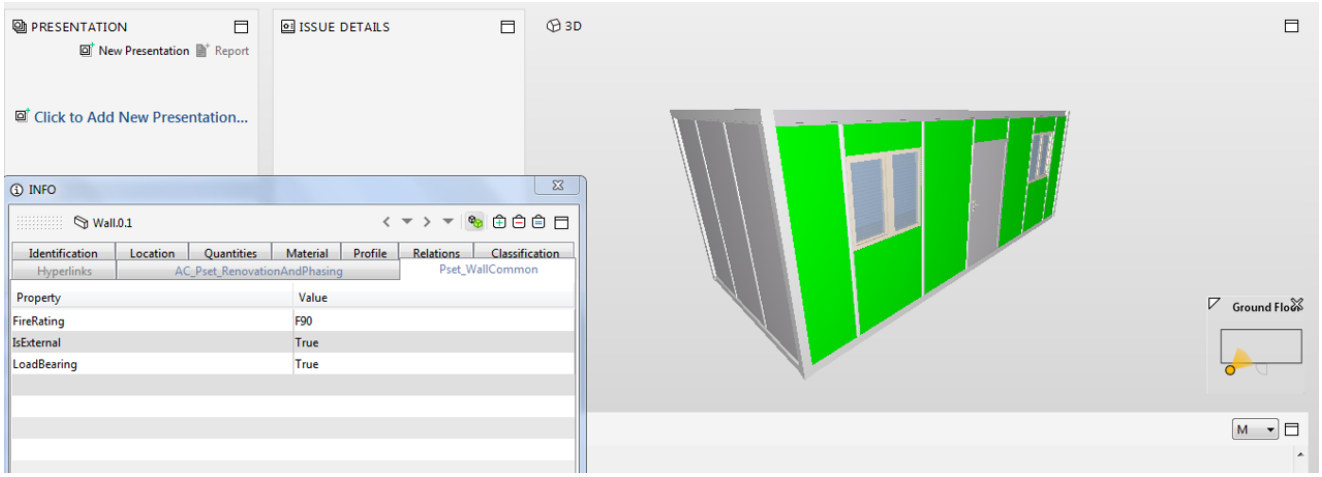
An advantage of a containerized building against a classical building is that the QC/QA would be performed at the factory. Unless it's a modular building, a final assessment would be performed after assembly on site, in a case when 2 or more inter-modal units would be assembled together on site, then QC/QA is inevitable and, in most of the cases, mandatory. Those issues, which occur within the factory, are easy to eliminate, and necessary building parts could be changed/repared in a short time manner. However, it's not a common practice that a building would be tested (Blower Door test or IR Thermal Imaging) in the factory unless it should meet some Building Energy Standards like Passivhaus Standard or local Energy Codes like California Energy Code or even targeting some Green Building

Certifications like USGBC LEED or BREEAM etc.). Usually Factory Assembled Buildings are being planned with the help of BIM Methods and Standards. In most of the cases architects, who work closely with Sales Department, would design a building, and further Engineering department would develop their parts based on the reference model. In that case, BCF would be the best approach to exchanging information during the planning stage. Extending its use to manufacturing would also be a win-win situation for the entire team. However, many manufacturing systems currently don't support IFC-Schema...for that reason, some international initiatives are to come. See bSI Building Room for Steel Construction, which aims to update MVD for Steel Fabrication from IFC2x3 Schema into IFC4.3, or the recently released final Standard of IFC4precast covers the precast concrete industry.

In fact, new pioneer factories have started to work with openBIM Standards and implement them not only in steel construction but also in Timber Construction. An IFC Model, in this case, could be easily exported and further used when planning prefabricated buildings, which allows to the extraction of QTo from building models. In fact, those models could also be used for simulations: Whole Building Energy Modeling, Daylight Analyses, Manufacturing and Assembly Sequences 4D & 5D, Thermal bridge Analyses, Asset Operation, Visualisation etc. However, traditional 2D and 3D drawings in most factories remain a common practice.



Typical Containerized Building prior to shipment to the site (Source: Mirbek Bekboliev, 2014)



IFC Model of the Typical Containerized Building (Source: Mirbek Bekboliev, 2014)

Site Usage (10 years later) as a Construction Site Office for Foreman

Narrative: ???

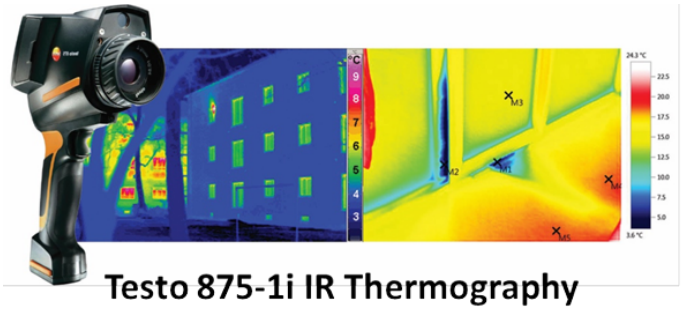
Typical Containerized Building on a construction site, being used as a Forman's Office (Source: Mirbek Bekboliev, 2015)

Capturing Real Data from Site - Digitalisation of existing Asset

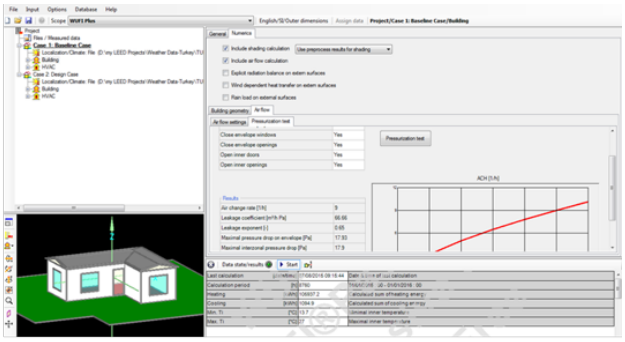
Issues, e.g. after 10 Years – Energy Retrofit (Renovation)

Narrative: ???

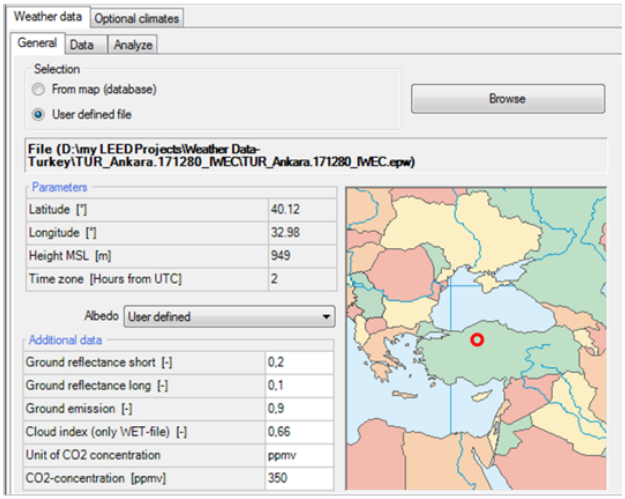
- Capturing Water Usage
- Capturing Energy Usage / Energy Monitoring
- Existing Condition of Built Asset (Walls, Windows, Doors, Electrical, HVAC, Plumbing Utilities etc.)
- R-value Measurements
- Blower Door Measurements
- IR Thermography Measurements
- Energy Simulations pre and post-Retrofit Cases



Testo 875-1i IR Thermography



Minneapolis Blower Door



WUFI Plus 3.0+Ankara Weather

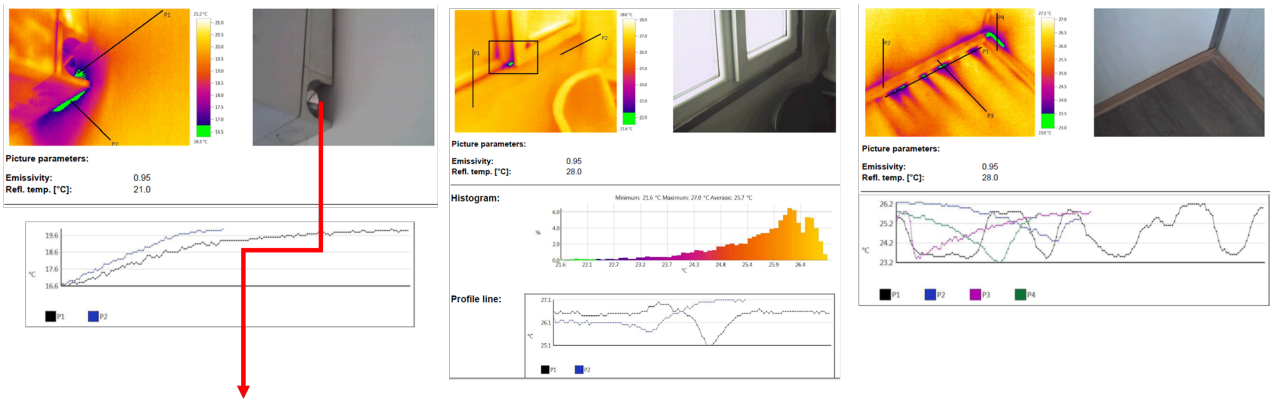
Airtightness Assessment and Documentation Tools (Source: Mirbek Bekboliev, 2015)

Evaluation of the Airtightness of the Pre-Retrofit Case

Narrative: ???

Why Blower Door and IR Thermal Imaging? Narrative!!

According to Passivhaus Institute, in Germany, a target value for new buildings was first introduced by the German Energy Saving Ordinance (EnEv) on 01.02.2001, currently changed with GEG (Building Energy Code). Specific values for the pressurisation test (n50-values) should not exceed 3 h-1 without ventilation systems and 1.5 h-1 with ventilation.



Building Envelope Issues occurred during the assessment of the container building (Source: Mirbek Bekboliev, 2014)

BCF & Issue Management

Step 1

Video 1

https://youtu.be/ywWt4GWH9xs

Step 2

Video 2

https://youtu.be/sdLwdbtfYZg

Step 3

Video 3

https://youtu.be/t-Bht130pwg

Step 4

Video 4

https://youtu.be/grBt7Tq9vf4

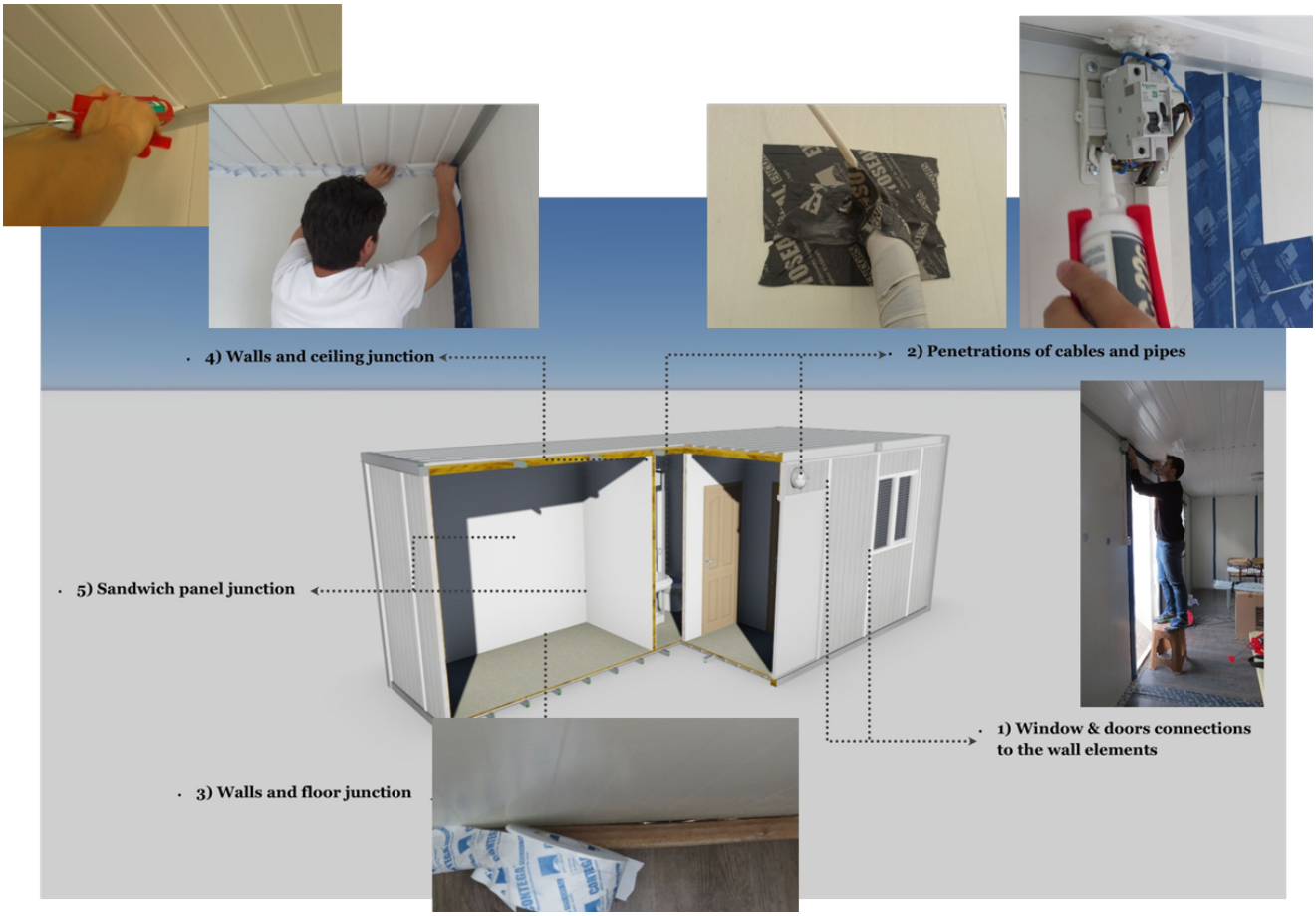
Step 5

Video 5

https://youtu.be/jrpfUfGvOy0

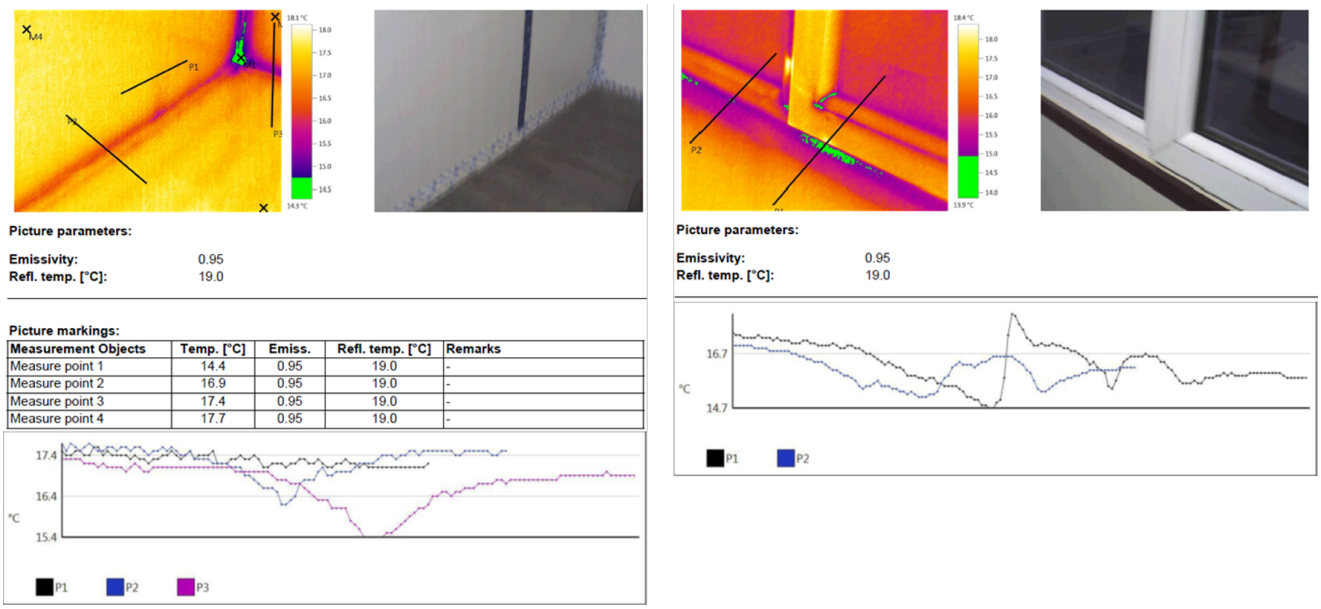
Retrofit Procedure aka Improvements

Narrative: ???

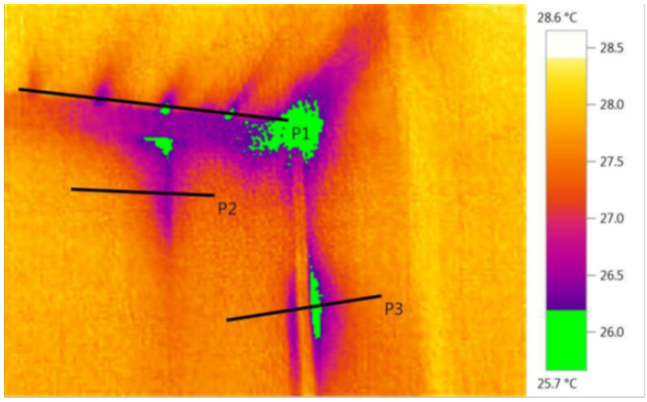


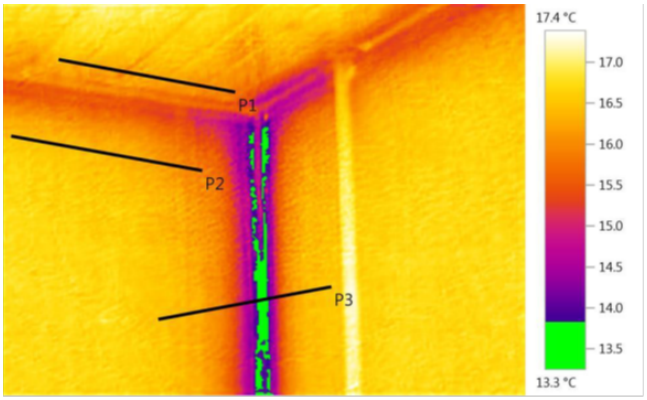
Applied Improvements on Airtightness Level (Source: Mirbek Bekboliev, 2014)

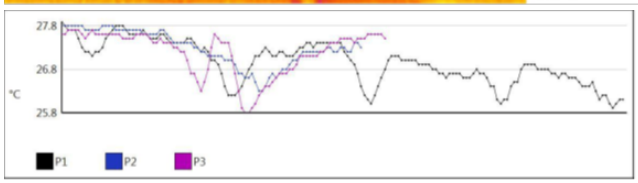
Evaluation of the Airtightness of the Post-Retrofit Case

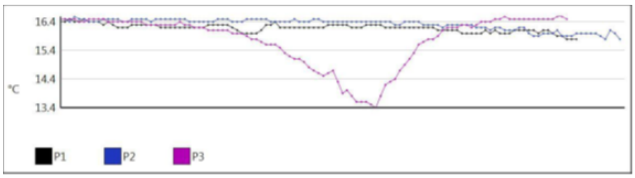


Thermal Imaging during the Blower Door Test of the Containerized Building (Source: Mirbek Bekboliev, 2015)







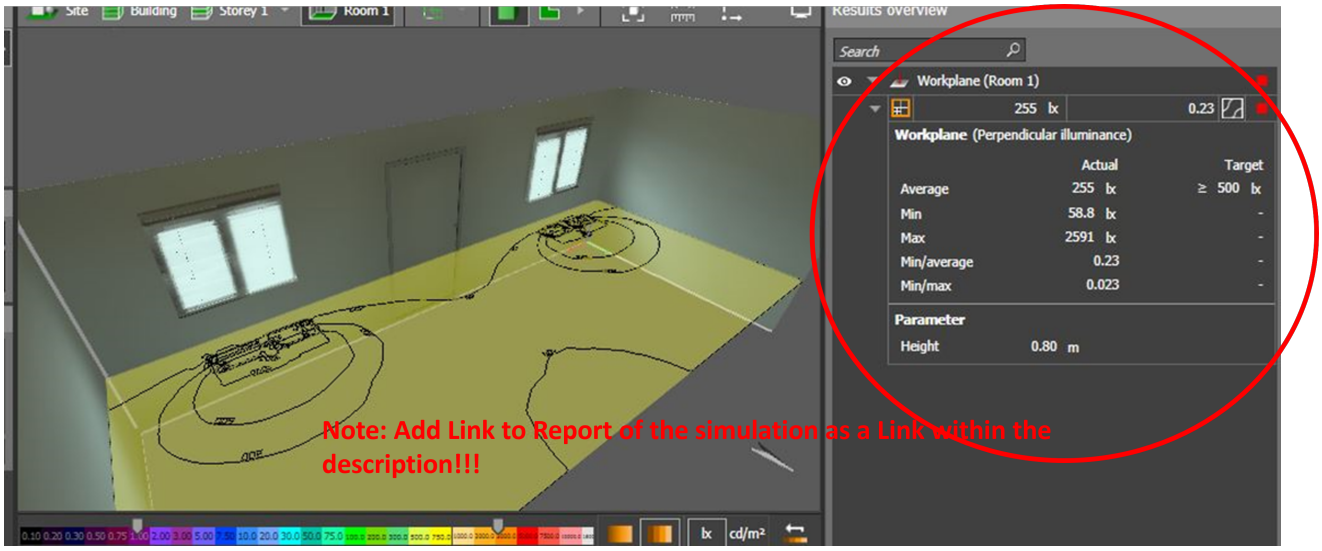


PRE-RETROFIT CASE	POST-RETROFIT CASE
Emissivity: 0.95 (data obtained from Testo Database)	Emissivity: 0.95 (data obtained from Testo Database)
Relative Humidity: 30% Rh	Relative Humidity: 45% Rh
Reflected temperature: +28ºC	Reflected temperature: +19ºC
Indoor temperature: +28ºC	Indoor temperature: +19ºC
Outdoor temperature: min. +24ºC; max. +27ºC	Outdoor temperature: min. +16ºC; max. +21ºC
Measurement date/time: 09.06.2015 at 14:57	Measurement date/time: 14.10.2015 at 18:50
ΔTinterior-exterior=28ºC-24ºC =4 ºC	ΔTinterior-exterior=19ºC-16ºC =3 ºC
ΔTinterior-ceiling=28ºC-27.9ºC =0.1 ºC	ΔTinterior-ceiling=19ºC-16.9ºC =2.1 ºC
ΔTinterior-left wall=28ºC-26.3ºC =1.7 ºC	ΔTinterior-left wall=19ºC-15.2ºC =3.8 ºC
ΔTinterior-right wall=28ºC-25.7ºC =2.3 ºC	ΔTinterior-right wall=19ºC-14.6ºC =4.4 ºC
ΔTinterior-ceiling profile=28ºC-26ºC =2 ºC	ΔTinterior-ceiling=19ºC-26ºC =2 ºC
ΔTinterior-ceiling corrugation=28ºC-25.9ºC =2.1 ºC	ΔTleft wall-right wall=19ºC-13.3ºC =5.7 ºC

Comparison of the IR Thermal Imaging of the same Container Building Pre and Post Improvement Cases (Source: Mirbek Bekboliev, 2015)

Further Analyses were performed with the IFC Model

Vital Note: Exchange Requirements are Vital. It's important to know which IFC-Schema and its entities and types of simulation software support. E. g. DIALux Evo has been performed for Daylight Analyses, where the IFC2x3 schema is being used. Thus related MVD (Model View Definition) has been used, in this case, IFC2x3 CV.



Daylight Simulation based on IFC2x3 CV on DIALux Evo (Source: Mirbek Bekboliev, 2015)

What can we do with the existing buildings?

How do we digitalize existing assets?

A portfolio manager of multiple schools in Switzerland would like to have documentation about their existing school building to be able to have a better understanding of the condition of their assets. The goal is the data capturing to allow the portfolio manager to better predict the required budget for maintenance and repair costs and better understand the end lifetime of several parts of the building.

Building Info:

- School Building in Rapperswil Switzerland
- 6 Story Building
- 35 Rooms
- build in the 1950s
- Renovated multiple times
- Paper drawings

A sample School Building (Source: Gianluca Genova, 2021)

Capturing Geometrical Data with Photogrammetry

There are multiple ways of capturing data from existing buildings. Different data-capturing technologies and methods have advantages and disadvantages in various conditions like limited light, enough space, accessibility or height limits. Also, these other methods can capture different types of data sets that suit different parts of the building better to get better qualitative data. Usually, a combination of these methods gives the best results to have better documentation for the facility. For interior rooms, 360 cameras in combination with mobile lidar scanning technologies are sufficient, and for exterior surfaces like facades and roofs, drones do a better job.

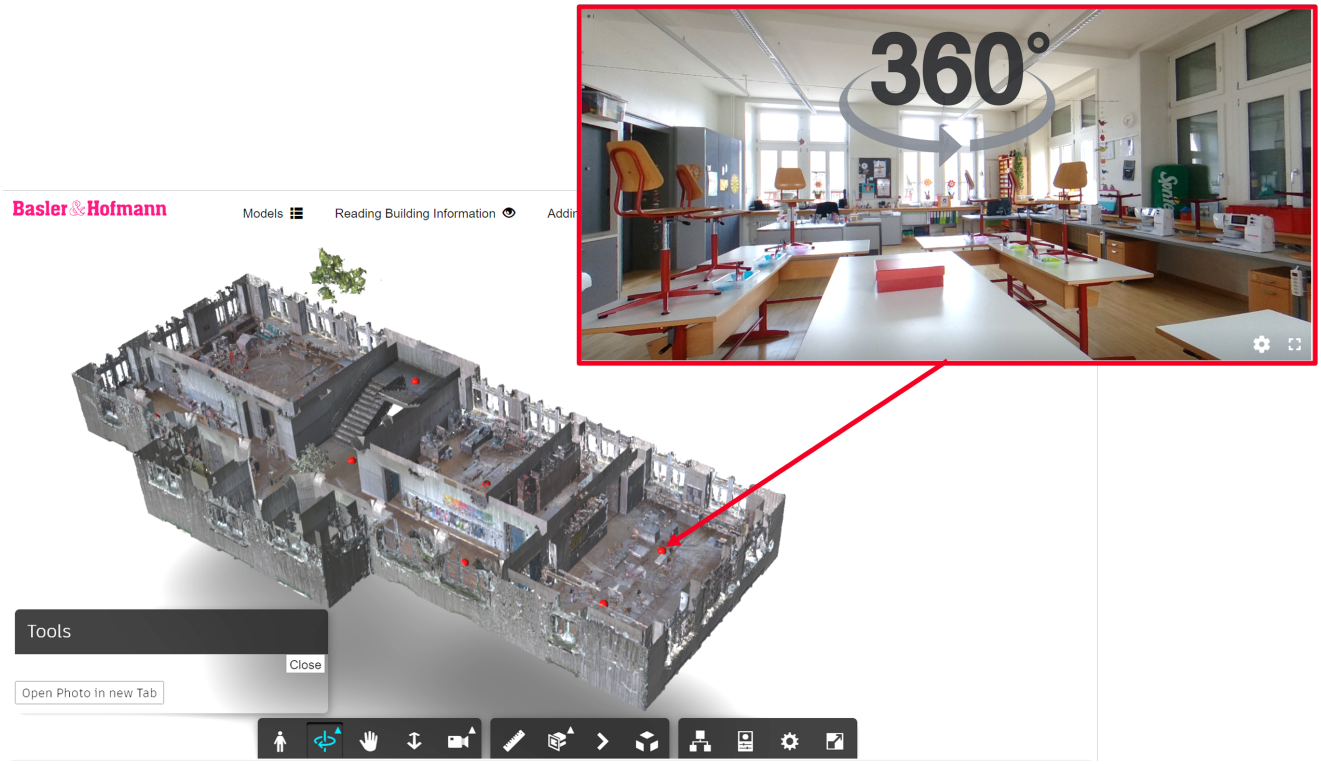
- Capturing Data with 3D Scanning with multiple devices
    - Lidar Scan with Drone
    - 360 Camera
    - The portable laser imaging scanner
- Merging Data into one Mesh Model with embodied 360 Images

Capturing Tools (Source: Gianluca Genova, 2021)

Embedding 360 images into the Mesh Model

The mesh model generated by point clouds, besides having accurate dimensions, usually has a lot of distribution on the texture, making it hard to recognise any material or conditional situation about the elements within the building. But having 360 photos from the interior rooms within the mesh model could be handy to compensate for the compromises made by mesh models. If the direction of the 360 pictures and mesh model is synchronized, it also allows one-to-one comparisons with the image and space to understand the asset better.

- Mesh models have a terrible visual quality
- Give a good idea about the geometry
- Help for Navigating /Recognition within the digital assets



Embedding of Models (Source: Gianluca Genova, 2021)

Creating a Digital Twin Platform for Existing Buildings

https://youtu.be/oxcdVMB4Xpc Platform Functions

Recognizing Room Boundaries and Levels

https://youtu.be/vQdfr-Hg30Q Boundaries

https://youtu.be/XDpg372FDpE Levels

Generating an Issue in a Mesh Model

https://youtu.be/Cqh9mV0zPwo Adding Issues

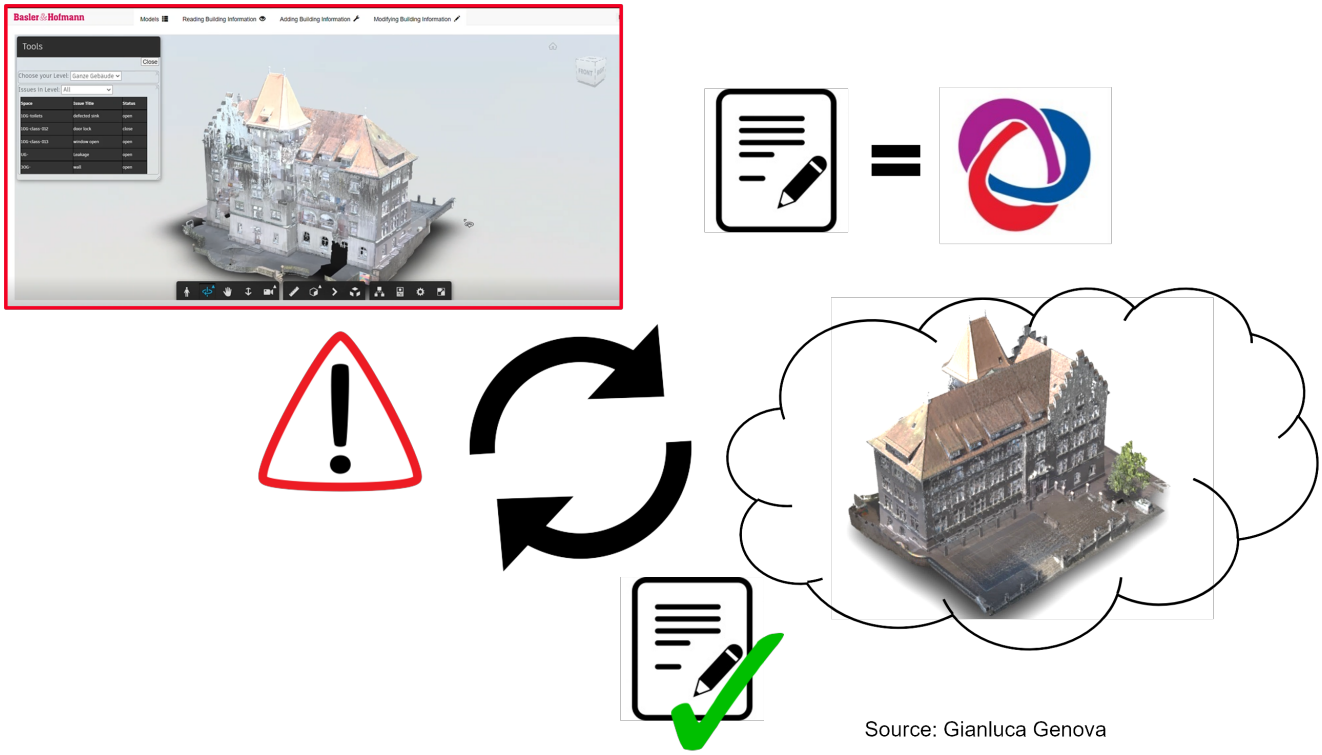
Linking the Issue with Model and 360 Image

https://youtu.be/KCD11hBBrc8 Adding Issues on a 360 Image

Further use of BCF for Building Owner

The BIM Collaboration Format (BCF) generally allows different BIM applications to communicate model-based issues. This issue usually contains textual comments, screenshots, related objects and location information. Since we are building a Hybrid model with Mesh and curation spatial elements (ifcSpace or placeholders), this will enable us to use BCF the same way we use our BIM Workflows.

The issues can be converted to BCFs
Issues holder objects can be exported as IFCs
The Issue Holder Objects can be merged with the mesh model and stored in a cloud for further BCF-based applications.



Source: Gianluca Genova, 2021

Virtual Reality / Augmented Reality and BCF & Issue Management

Narrative by Jeffrey

References

- Bekboliev, Mirbek. 2015. “Assessing the Airtightness Performance of Container-Like Buildings in Relation to Its Effect on Energy Efficiency.” M.S. - Master of Science, Middle East Technical University. https://open.metu.edu.tr/handle/11511/25346
- bSI Virtual Summit - BR3 https://vimeo.com/637428633

Abbreviation

BCF - BIM Collaboration Format

The BCF standard version 2.1 defines two possible transmission paths:

- File-based (bcfXML. bcfZIP) or
- per Webservice (bcfAPI)

Here is a short explaination of BCF -> https://www.youtube.com/watch?v=yrm5SrEfSvE

See also -> https://www.buildingsmart.org/standards/bsi-standards/bim-collaboration-format-bcf/

References

DIN EN ISO 29481-1:2018-01
Building information models - Information delivery manual - Part 1: Methodology and format (ISO 29481-1:2016); German version EN ISO 29481-1:2017

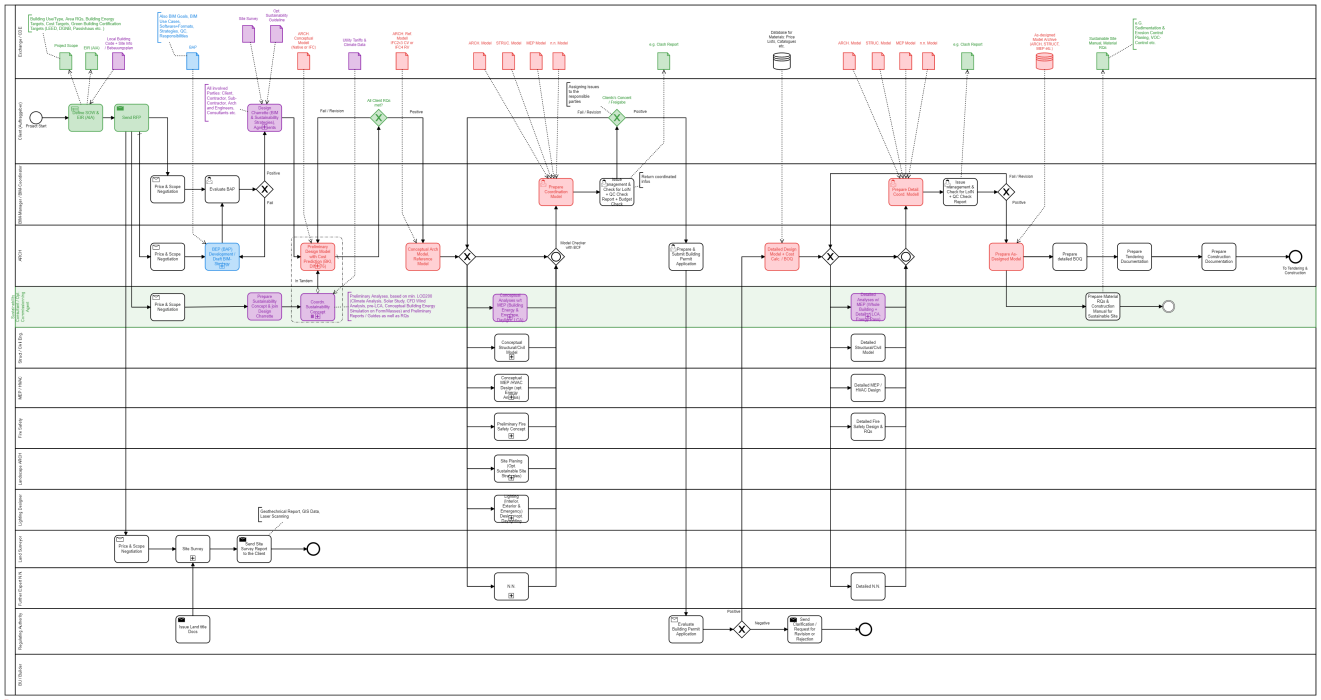
ISO 29481-1:2016
Building information models — Information delivery manual — Part 1: Methodology and format

Process Definition

ISO 22263

Stage - Introduction

Description



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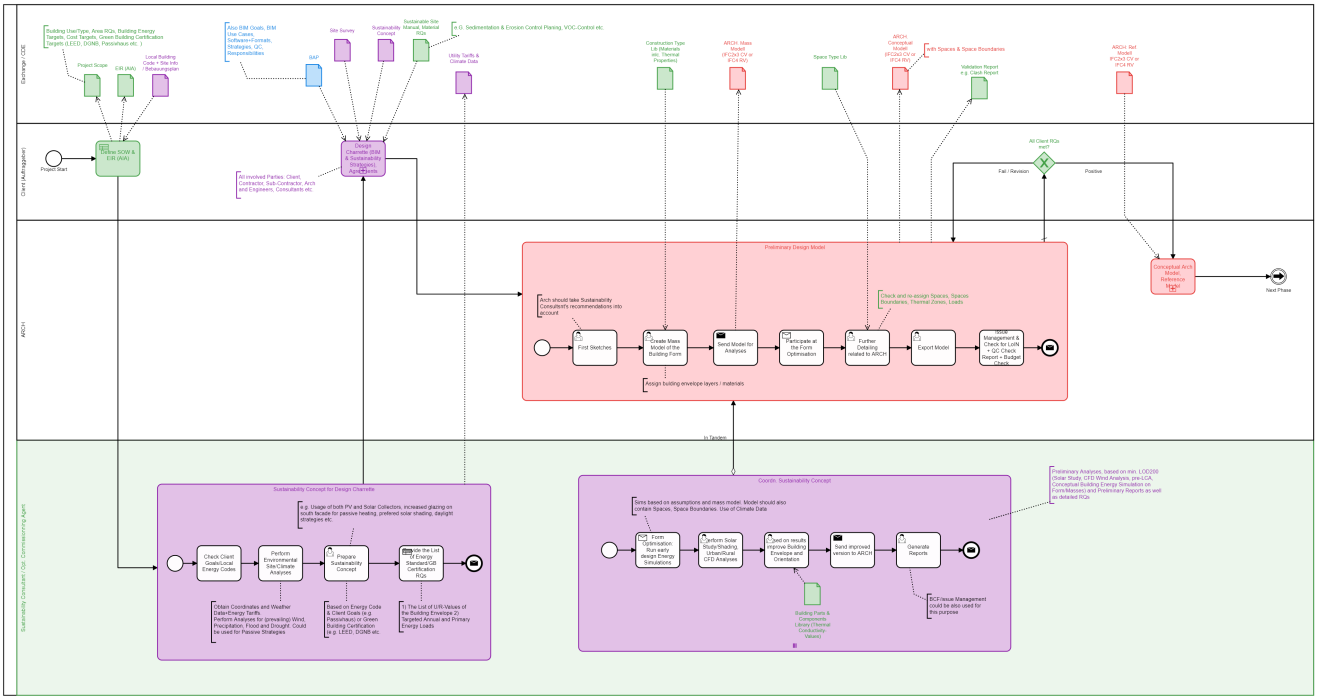

Source in HD: https://cawemo.com/share/88caafed-ecf8-4d93-86b9-55d333ef8c5a

Exchange Requirements

Description

Required Info:

- Identify the tested object: Address, construction date, architect
- Standard used (EN 13829 - method A)
- Which part of the building were tested (floors, areas included, excluded etc)
- Net floor area (TFA) and internal volume of the space (V n50)
- Documentation of verification of V n50 calculations
- Elevation of building, height of the building
- Status of all opening in the building enclosure (sealed, open, closed, locked)
- Description of temporary seals
- Make and model of blowerdoor, serial number - date of last calibration
- Baseline pressure differences
- Inside and outside temperatures (Celcius)
- Windspeed or beaufort scale
- Table of pressure differences and air flow rates (generated by software or derived in manual test)
- Air leakage graph
- Air change rate, n50, at 50Pa for pressurization, depressurization and mean value of the two.
- Test date

Required Information to perform Building Envelope Assessment through Blower Door and IR Thermal Imaging:

- Building Model (with related Properties: Location/Address, Owner etc.)
    - Building Envelope with related Properties and Quantities
        - Total Building Envelope Volume
        - Total Building Area
    - Indication of the Building Entrance (For Blower Door Installation)
    - Indication of all Temporary Sealings (All Designed openings to be sealed: Air Intakes for AC Units, Louvers, Elevator Shafts, Hoods, etc.)
- Weather Condition (to be measured on Site, Indoor-Outdoor Temperatures and Humidity)
- Available Period for Assessment (1st Assesssment when the Building Envelope is enclosed and finishes are not yet applied; 2nd Assessment after the Imrpovements, when applicable and required)

Airtightness related Properties within the IFC4.3 Schema

ifcDoor

- Pset_DoorCommon

Property: Infiltration -

"Infiltration flowrate of outside air for the filler object based on the area of the filler object at a pressure level of 50 Pascals. It shall be used, if the length of all joints is unknown."

http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_DoorCommon.htm

ifcWindow

- Pset_WindowCommon

Property: Infiltration -

Source: http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_WindowCommon.htm

- Pset_Condition

Property: AssessmentCondition -

"The overall condition of a product based on an assessment of the contributions to the overall condition made by the various criteria considered. The meanings given to the values of assessed condition should be agreed and documented by local agreements. For instance, is overall condition measured on a scale of 1 - 10 or by assigning names such as Good, OK, Poor."

Source: http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_Condition.htm

ifcMaterial

- Pset_MaterialThermal

Property: ThermalConductivity -

"The thermal conductivity of the object. The rate at which thermal energy is transmitted through the material."

Source: http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_MaterialThermal.htm

ifcSite

- Pset_SiteWeather
- Pset_Address

IfcBuilding

- Pset_BuildingCommon

Source: http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_BuildingCommon.htm

- Pset_OutsideDesignCriteria

Properties: WeatherDataStation, WeatherDataDate, BuildingThermalExposure, PrevailingWindDirection, PrevailingWindVelocity

Source:
http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_OutsideDesignCriteria.htm

- Pset_BuildingUse

Source: http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_BuildingUse.htm

- Pset_SpaceCommon

Source: http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_SpaceCommon.htm

- Pset_ThermalLoad

Properties: InfiltrationDiversitySummer, InfiltrationDiversityWinter, TotalCoolingLoad, TotalHeatingLoad

Source: http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_ThermalLoad.htm

- Pset_SpaceOccupancyRequirements

Source:
http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Pset_SpaceOccupancyRequirements.htm

Vital required Infomation:

Qto_BuildingBaseQuantities
Source:
http://ifc43-docs.standards.buildingsmart.org/IFC/RELEASE/IFC4x3/HTML/lexical/Qto_BuildingBaseQuantities.htm

Note: Unfortunately following properties are not applicable to the windows or doors...

- Pset_DamperPHistory

Property: Leakage -

"Air leakage rate."

- Pset_DistributionSystemTypeVentilation

Property: LeakageClass -

"Nominal leakage rating for the system components."

Airtightness Classification and Properties in bSDD

- Airtightness surveying https://search.bsdd.buildingsmart.org/Classification/Index/5902
- Airtightness performance requirements https://search.bsdd.buildingsmart.org/Classification/Index/7544
- Air tightness according to EN 12114 https://search.bsdd.buildingsmart.org/Property/Index/105146
- Air tightness class according to EN 1751 (for Air Ducts)
  https://search.bsdd.buildingsmart.org/Property/Index/110611

Further Notes:

- **Air Leakages could be also indicated not only at the Door and Window Junctions but also at other areas like openings for HVAC and Plumbing (in this case not properly sealed ones) or at the junctions (between 2 Sandwich Panels, Roof and Wall Juctions, Wall and Floor Junctions)**
- **Thermal Bridges could occur at various locations, where no proper Thermal Breaks were applied or no insullation is available**

Software, Tools & Services

Tools

- BIM Authoring Tool (Optional) -> unless IFC-Model is available!
- Blower Door Test with Reporting Software (e. g. Minneapolis Blower Door)
- Anemometer (for Air Stream Speed tests)
- Infrared Thermal Imaging Camera
- IFC Viewer or Model Checker (e. g. Solibri, BIMcollab etc.)
- CDE Platform (Optional)
- Fogger (Optional)

Media

- IFC Model
- Thermal Imaging
- Blower Door Test Certificate
- BCF Reports

Imprint

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Restriction and handling

The documents reflect the current best practice and do not claim to be complete. They should not to be understood in the sense of a generally valid recommendation or guideline from a legal point of view. The documents are intended to support appointing and appointed parties in the application of the BIM method. The documents must be adapted to the specific project requirements in each case. The examples listed do not claim to be complete. Its information is based on findings from practical experience and is accordingly to be understood as best practice and not universally applicable. Since we are in a phase in which definitions are only emerging, the publisher cannot guarantee the correctness of individual contents.

Change Log

Date	Version	Class	Text	Author
2022-10-02 21:00	0.1	Added	1. Draft of the Use Case with Airtightness and Thermal Bridge Related Stuff. Inputs on Exchnage Requirements -> related IFC Classes, Psets and their properties as well as Quantity Sets. Related Information on BCF, Blower Door testing Input on required Tools and SW as well as Formats	Mirbek Bekboliev