



BIM based fast toolkit for
Efficient rEnovation in Buildings

www.bim4eeb-project.eu

Digital Twin for energy buildings' renovation based on new ontologies and linked data

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POLITECNICO
MILANO 1863



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BIM4EEB General objectives

An EU-funded project supporting the renovation industry in retrofitting existing residential buildings with a complete

BIM-based toolkit for Efficient rEnovation in Buildings, in order to :

- **make the flow of information efficient**
- **decrease intervention working time,**
- **improve building performances, quality and comfort for inhabitants.**



The BIM4EEB specific objectives

O1. Maximise efficiency in building renovation:

- Renovation working time reduction (20%)
- Renovation costs reduction (15%)
- Building quality control with less than 10% performance gap
- Faster energy audits -50% of time
- Net primary energy use decrease (10%)

O2. Accelerate the market uptake across Europe towards a digital built environment:

- Uptake of BIM-based renovation by construction companies (50%)
- Uptake of BIM-based dynamic energy assessment plus 30%
- Connection of BIM and GIS environments
- Implementation of as-built data collection in logbooks



The BIM4EEB objectives

O3. Speed-up data gathering and processing

- Fast mapping tools for acquiring data of existing buildings and creating BIM models (30% time reduction)
- Innovative tools for connecting BIM models and BACS
- Improved performance and environmental data monitoring/ analysis to support decision-making on renovation scenarios (30% time reduction)
- Occupant behaviour data monitoring to enhance comfort, performance and building operation
- Enhanced simulation (performance gap of max. 10%)

O4. Interoperability of different stakeholders and tools, harmonising data exchange formats

- Improve the utilisation of increasingly heterogeneous building data by making it more accessible and interconnected
- Central, accessible, reusable platform for storing information
- Harmonised standardisation for data exchange formats
- Standardise data exchange between BACS and BIM



The project in a nutshell

CALL/Topic

- INDUSTRIAL SUSTAINABILITY - ENERGY-EFFICIENT BUILDINGS (EEB)
- LC-EEB-02-2018 Building information modelling adapted to efficient renovation (RIA)

ACTION ID

- BIM4EEB
- BIM based fast toolkit for Efficient rEnovation in Building:
- GA No. 820660

Duration:

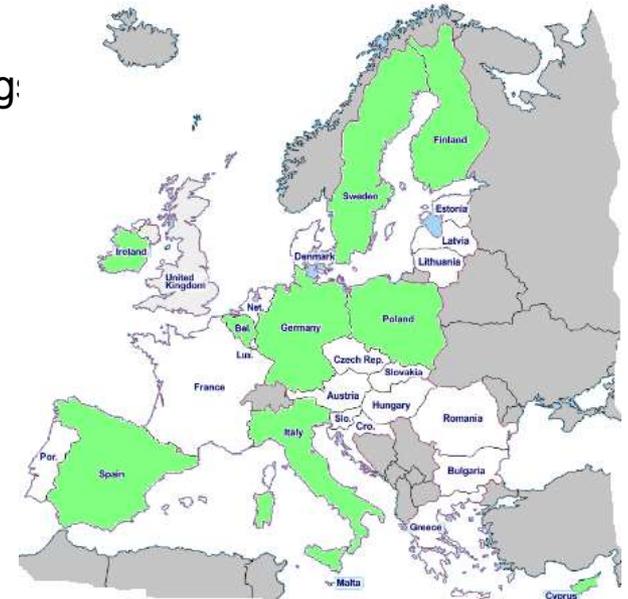
- 42 months - 1 January 2019 – 30 June 2022

Financial

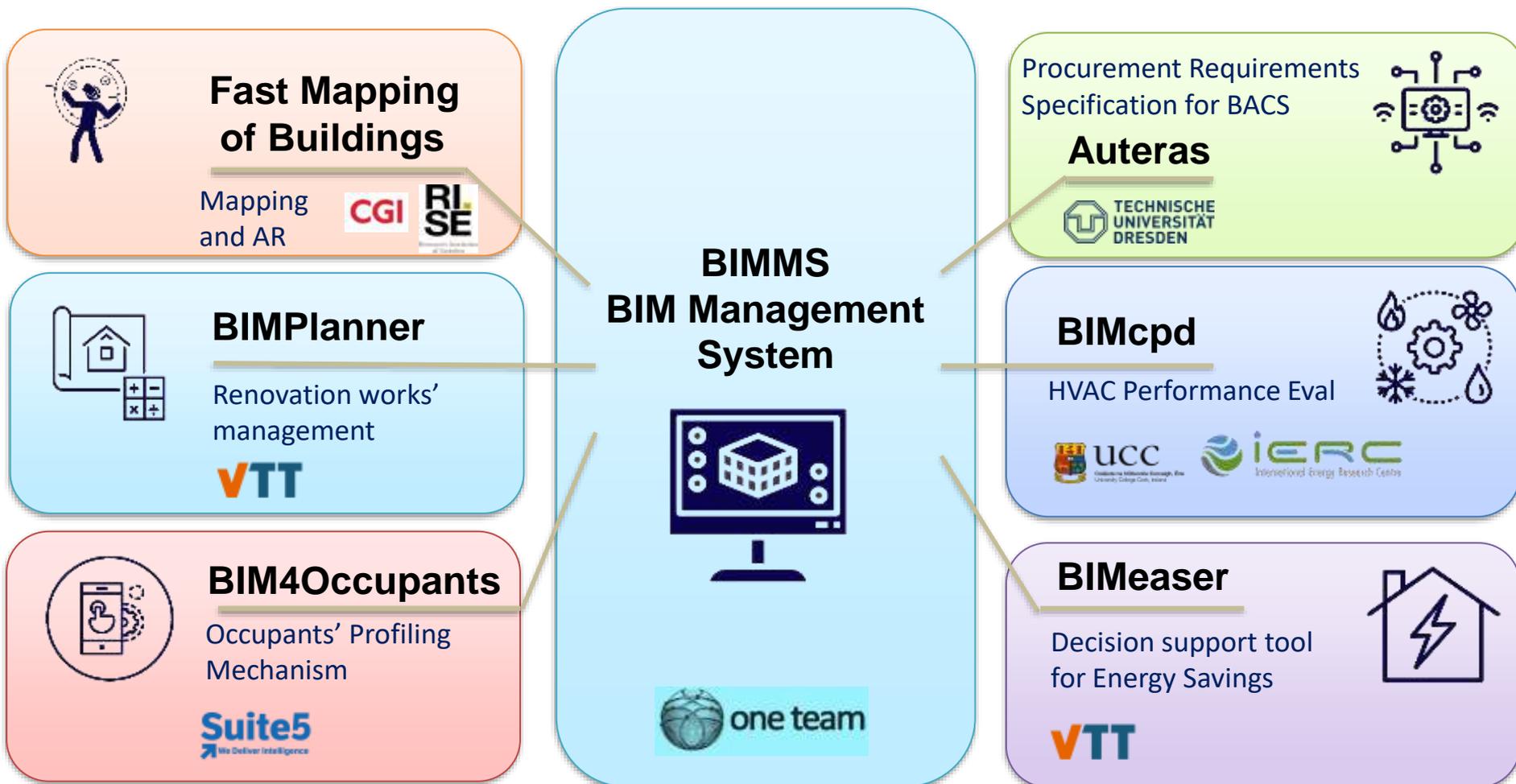
- Costs 6'933'940 EUR
- EC Funding 100%

15 partners representing main stakeholders

- 3 Universities: PoliMi, UCC, TUD
- 2 Research Institutes: VTT, RISE,
- 2 Public administrations: Lombardy Region / ALER VCBM
- 4 SMEs/ Start-ups: SOLINTEL, SUITE5, OneTeam, VisualLynk
- 3 Large Enterprises: CAVERION, GCI Sverige, PROCHEM
- 1 Association ACE



The BIM4EEB toolkit



From BIM towards Digital Twin

Common elements – 3D model viewer and IoT connection

The screenshot displays the BIM4EEB BIM viewer interface. At the top, it is titled "IFC Viewer". The main area shows a 3D model of a multi-story building. To the left, there is a "Hierarchy" tree with the following items:

- 0001 - IFCProject
 - apartment_40 - IFCZone
 - apartment_02 - IFCZone
 - apartment_38 - IFCZone
 - apartment_13 - IFCZone
 - apartment_46 - IFCZone
 - apartment_47 - IFCZone
 - apartment_30 - IFCZone
 - apartment_58 - IFCZone
 - apartment_32 - IFCZone
 - apartment_01 - IFCZone
 - apartment_00 - IFCZone
 - Outdoors - IFCZone

At the bottom of the interface, there is a toolbar with various icons for navigation and editing. A small "L" icon is visible in the bottom right corner of the main view area. The interface also includes a "Name: Type Material Properties" table on the right side, which is currently empty.

BIM4EEB – BIM viewer

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  APPS

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From BIM towards Digital Twin

The screenshot displays the BIM4EEB - IoT Data interface. The main view shows a 3D model of a building. On the left, there is a navigation menu with options like Home Page, Roles and rules, Resource manager, and BIM models. A 'Hierarchy' panel shows a tree structure of resources, including '0001 - IfcProject' and various 'apartment_...' and 'Outdoors - IfcZone' entries. A 'Linked Data' window is open, showing a table of linked data with columns for 'code' and 'type'. A 'Sensor Data' window is also open, showing a table of sensor data with columns for 'date', 'value', 'UM', and 'type'. The interface includes a search bar at the top right and a 'BIM4EEB' logo at the top left.

BIM4EEB - IoT Data

Italian demonstration site - NO STAGE - No Building - Administrat

Home Page Roles and rules Resource manager New resource Resource list Geo Linked Data New Linked Data Object Logbook Data List BIM models SPARQL Endpoint Ontology viewer 'A' Data streaming Sensors Measurements Import Sensors Import Measurements Tools Endpoints

Hierarchy Zones Groups

0001 - IfcProject
apartment_40 - IfcZone
apartment_02 - IfcZone
apartment_38 - IfcZone
apartment_13 - IfcZone
apartment_46 - IfcZone
apartment_47 - IfcZone
apartment_30 - IfcZone
apartment_59 - IfcZone
apartment_32 - IfcZone
apartment_01 - IfcZone
apartment_00 - IfcZone
Outdoors - IfcZone
apartme
apartme
apartme

Linked Data Add Resource Extend Data

Occupants Sensors Plants Surveys Others

code	type	
4559806-59c5-41cc-84ae-a8b625190df	Aeon Home Energy Meter	Details
5916121b-78b4-4318-b1f1-6157625a11f8	Aeon Multisensor S	Details
e04c77e9-09a4-410f-be23-5cbe9d08d2f7	Netatmo Health Coach	Details
1850cbc2-7516-4029-ac08-7fb57419e15	Aeon Home Energy Meter	Details

Sensor Data

date	value	UM	type
13/01/2022 17:35:06	721	ppm	carbonDioxide
13/01/2022 17:35:06	26	%	Humidity
13/01/2022 17:35:06	50	dB	soundPressureLevel
13/01/2022 17:35:06	22	C	Temperature
13/01/2022 17:05:19	709	ppm	carbonDioxide
13/01/2022 17:05:19	26	%	Humidity
13/01/2022 17:05:19	44	dB	soundPressureLevel
13/01/2022 17:05:19	21,9	C	Temperature
13/01/2022 16:36:27	751	ppm	carbonDioxide
13/01/2022 16:36:27	26	%	Humidity
13/01/2022 16:36:27	21,9	C	Temperature
13/01/2022 16:36:27	72	dB	soundPressureLevel

Prop Hide Hide type Clip Unclip Prj data Auto Zoom

From BIM towards Digital Twin

Digital Logbook to manage the building and its renovation interventions

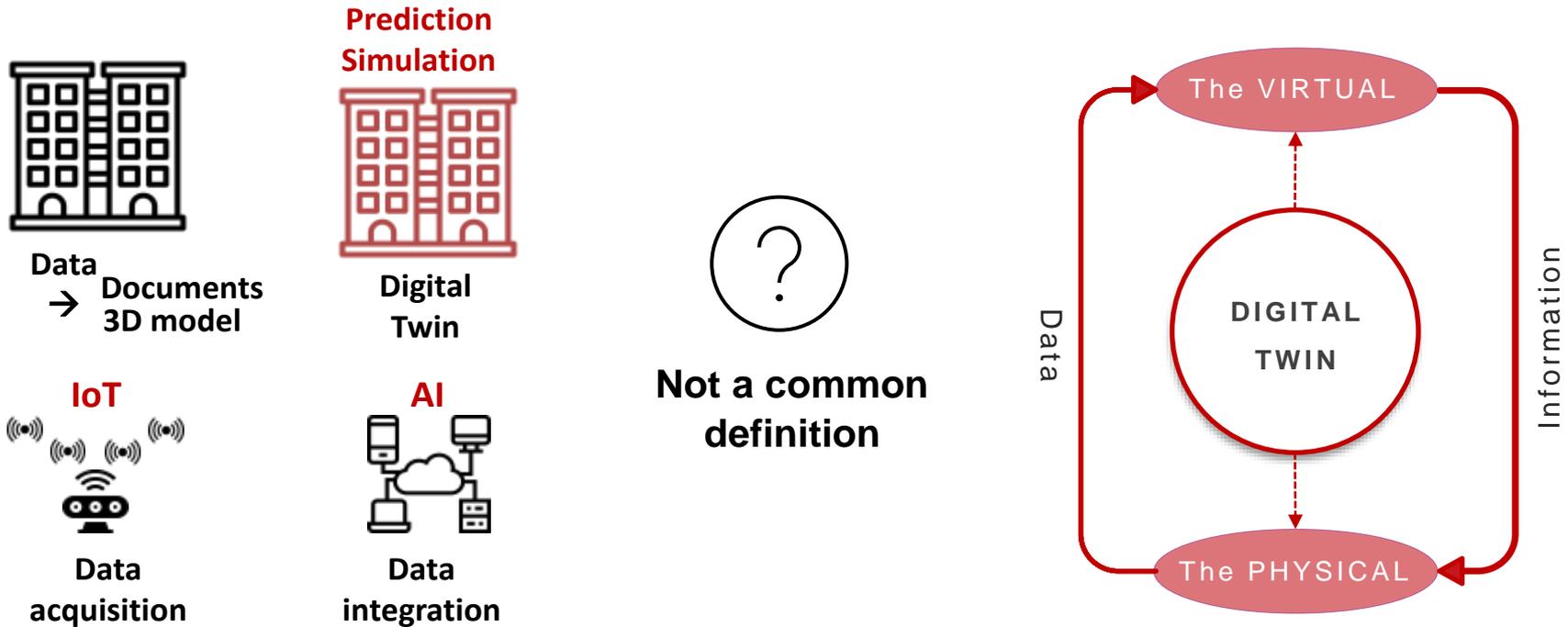
The screenshot displays the BIM4EEB Digital Logbook interface. The main window is titled 'Resource Data' and 'Digital Logbook'. A sidebar on the left contains navigation options: Home Page, Roles and rules, Resource management, Logbook Data List, and BIM models. The main content area has tabs for Element, Info, Values, Linked Data, Geo Linked Data, Document, IFC Linked data, and History. A list of categories is shown: General and administrative information, Building construction information, Building Energy Performance, Building Operation and Use, and SMART information. A detailed view of 'General and administrative information' is shown in a larger window, containing a table of building data.

Building ID	
Name of the building	Main destination (Residential, Commercial, Industrial, etc.)
Other destinations (if any)	Building category (Single-family detached, Single-family attached, Large multi-family, Office, Retail, Hotels, Special-purpose, Manufacturing, Warehouse/distribution, etc.)
Building permit ID (Amnesties)	Construction year
Last renovation (partial or general) year	Energy class
Cadastral ID (Cadastral sheet, Cadastral map)	Building address (Nation, Province, Town, Postal code, Street/Road/Square, Nr)
GIS coordinates, Longitude DD	GIS coordinates, Latitude DD
Height above the sea level m	Distance from sea m
Max number of occupants	

Below the table, there are sections for Registry, Urban and services data, Geotechnical and Geological data, Tender agreement, and Dimensional data.

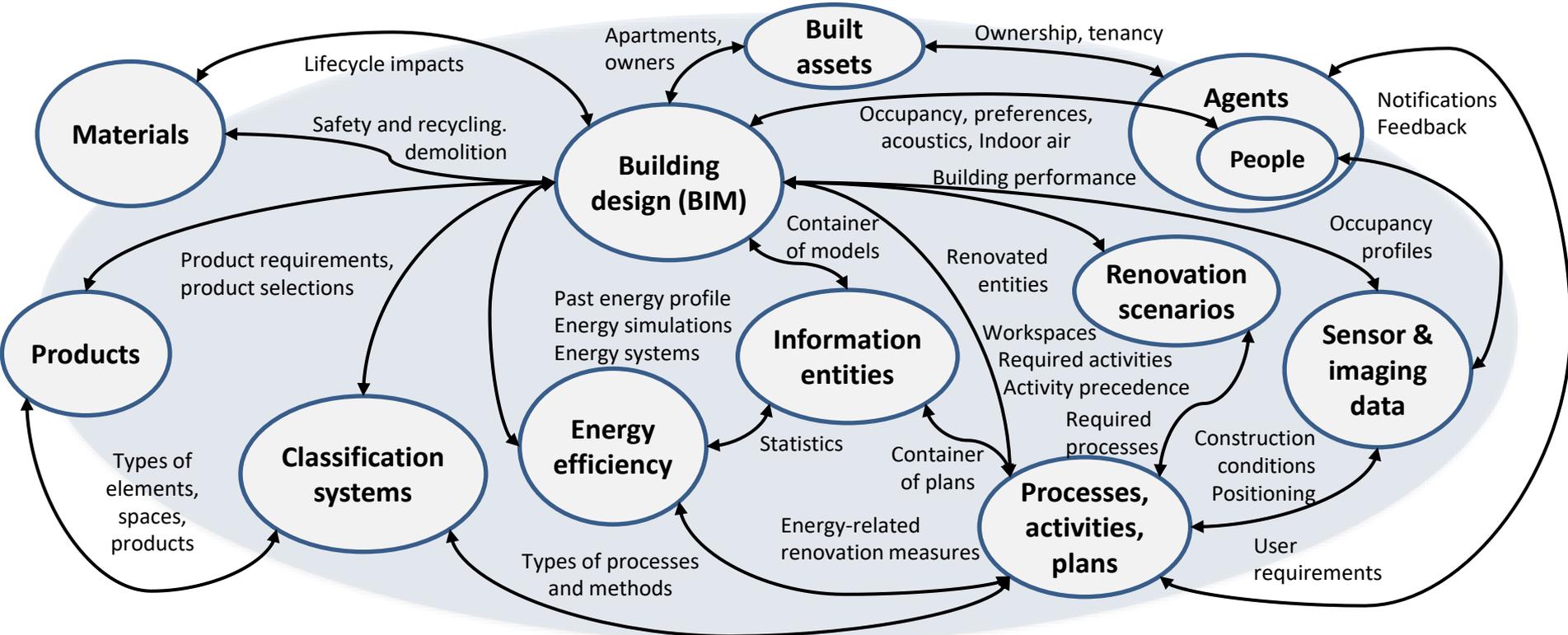
Operational tool

DIGITAL TWIN definition

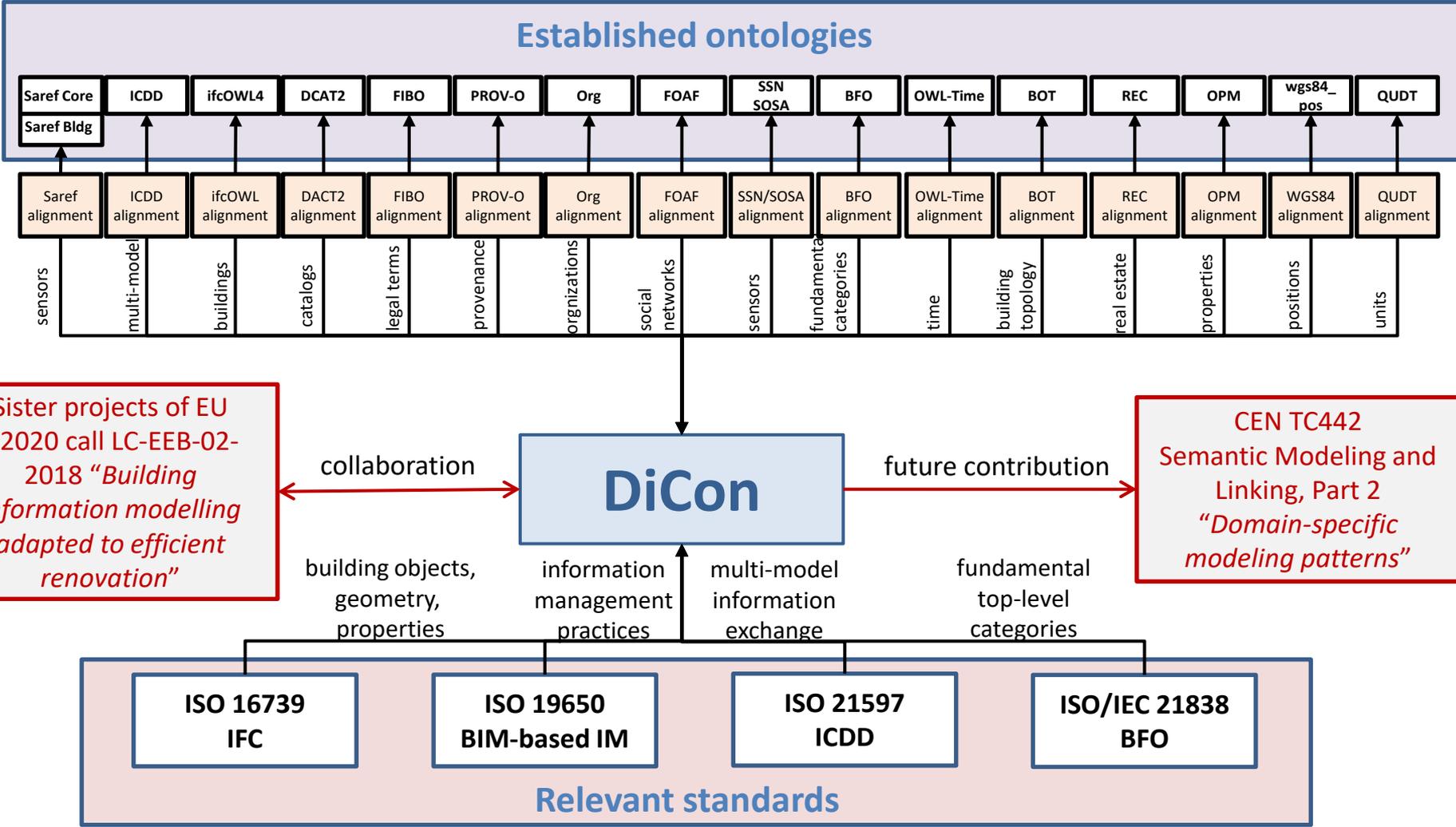


- “a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level” *Grieves & Vickers*
- “a digital duplicate of the physical environment, states and processes. While a BIM model contains as-is and historical data, a DT can be used to assess the current state, and to potentially forecast the future state” *Stojanovic et al.*
- “a realistic digital representation of assets, processes, or systems in the built or natural environment” *Bolton et al.*

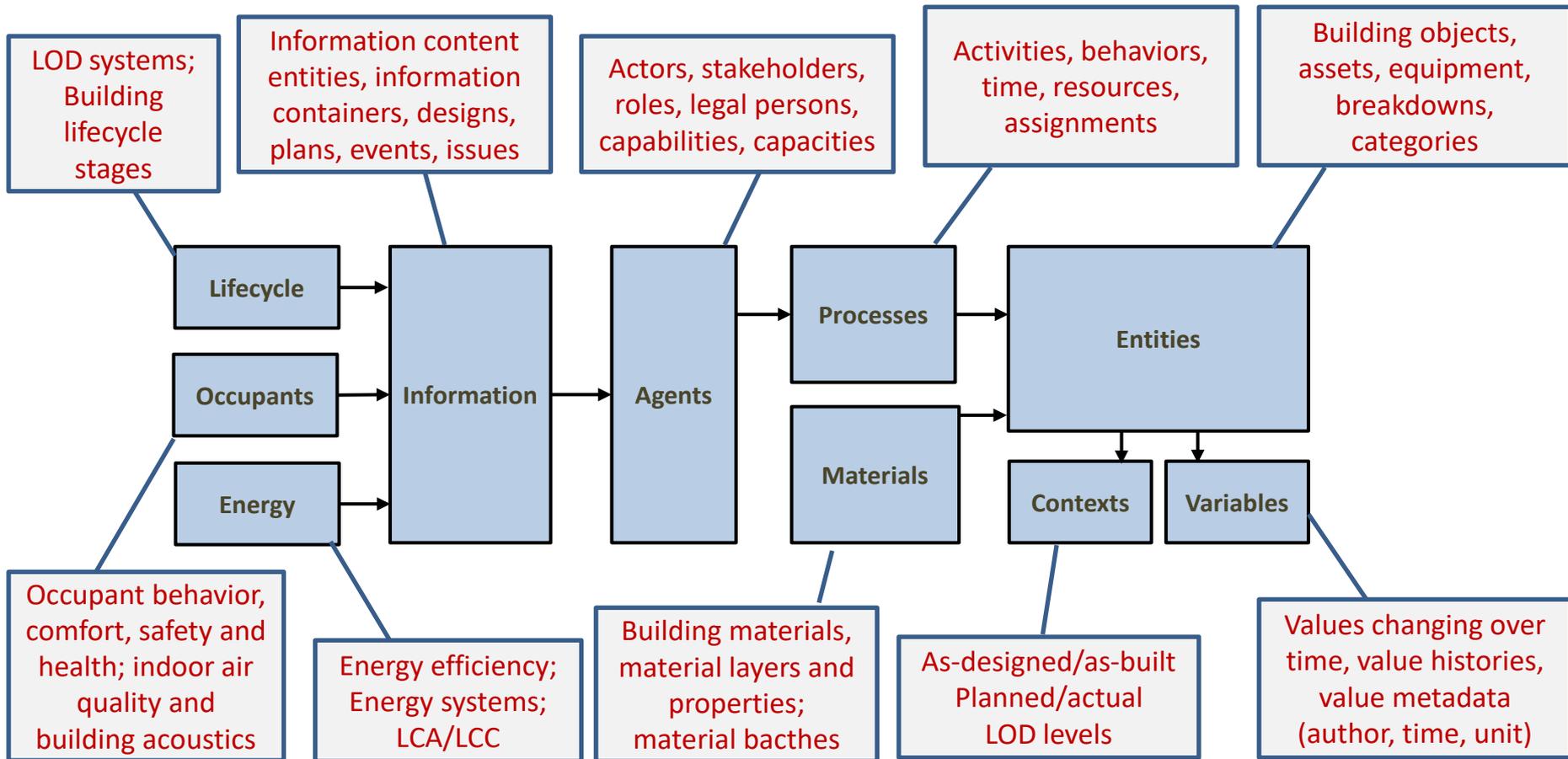
Areas of the renovation terminology



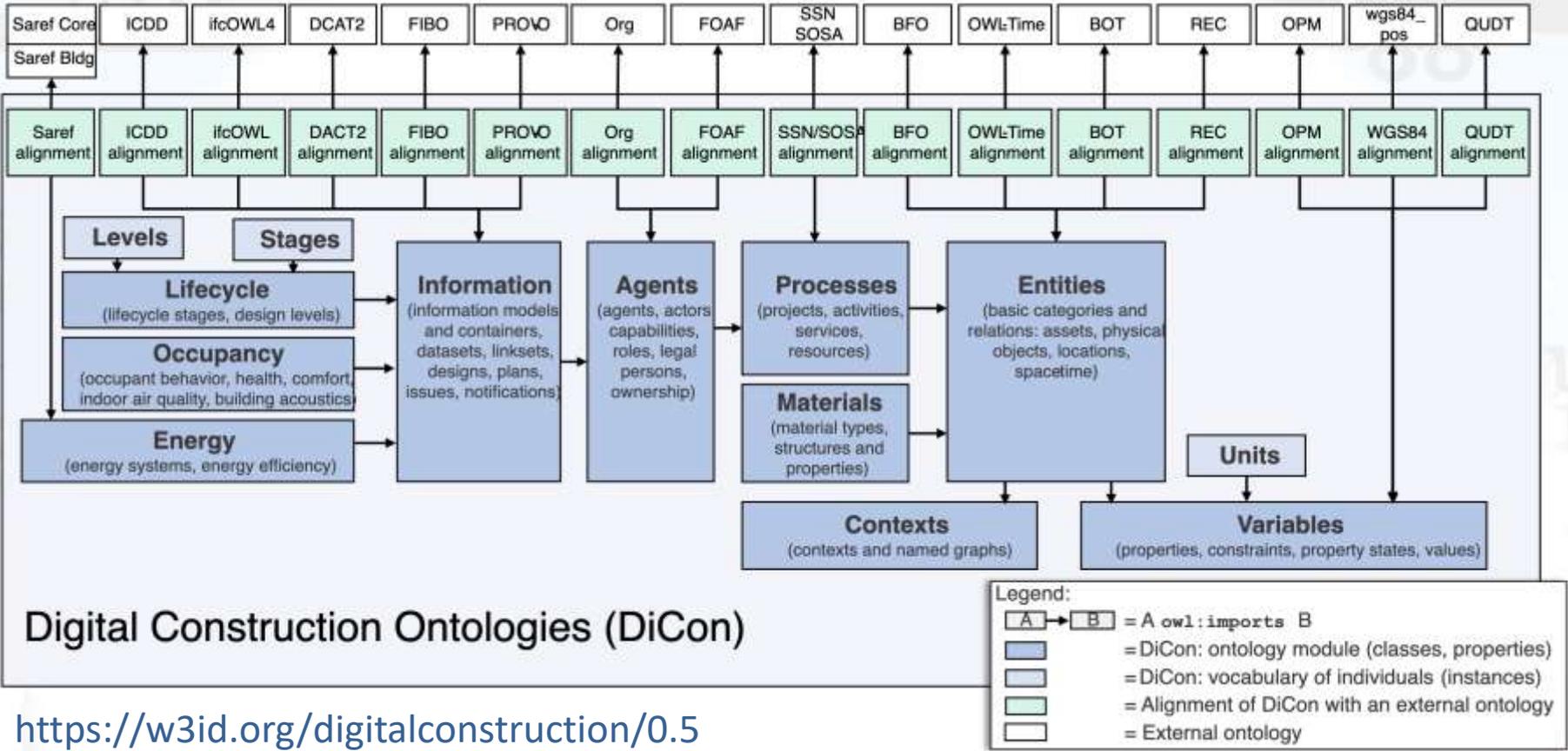
DiCon relations



Modules of DiCon



Digital Construction Ontologies (DiCon)



<https://w3id.org/digitalconstruction/0.5>



Comparison with sister Ontologies

Ontology	Description	Reused ontologies
BIM-SPEED		No direct reuse
Reno-Inst	Installation of windows, ETICS panels, and radiators in renovation projects.	–
LCA-C	LCA/LCC assessments, the assessed building, and the products/materials	–
BEM-Reno	A renovation ontology based on the structure of BOT, albeit not reusing it	Copy, adapt and extend BOT
BIMERR		Reuse by reference
Occupancy Profile	Occupants behavior inside buildings for the BIMERR project	Saref, Saref4Building, OWL-Time, SKOS, FOAF
Sensor Data	Sensors located inside buildings for the BIMERR project	Saref
KPI	Key performance indicators related to building renovation works	Saref, Saref4City, OWL-Time
Weather	Weather data for the BIMERR project	Geo, Saref, SSN, SOSA, Saref4City
Building	Building data for the BIMERR project	BOT
Material Properties	Properties to describe building elements in BIMERR	Saref
Annotations Objects	Annotations and extra information of building elements	–
Information Objects	The files and documents attached to building elements	–
Renovation Process	The construction processes in a building renovation	Saref
Metadata	Annotations for ontology to data model transformation	–
BIM4REN		No direct reuse
buildings	Elements related to a basic description of a building, inspired by BOT	Copy, adapt and extend BOT
buildingcomponents	Components of the building that as walls, windows, ...	–
buildingsystems	HVAC, domestic hot water, lighting and appliances.	–
occupancy	Occupants and their activities within the building	–
energy	Energy modeling of the building.	–
BIM4EEB		Reuse by alignment
Contexts	Multi-contexts data: planned/actual, as-designed/as-built	ifcOWL
Variables	Objectified properties for time varying values, constraints, value metadata	QUDT, Geo, OPM, ifcOWL, PROV-O, SSN/SOSA, Saref
Entities	Basic categories with identifiers, classifications, breakdowns, and groupings	BFO, Geo, ifcOWL, OWL-Time, FOAF, Org, BOT, REC, SSN/SOSA, S4Bldg
Processes	Activities and resources, resource assignments, and objects of activities	ifcOWL, FOAF, PROV-O, REC, Saref
Agents	Actors, stakeholders, roles, legal persons, capabilities, capacities	ifcOWL, Org, FOAF, FIBO, ICDD, REC
Information	Information content entities, containers, designs, plans, events, issues	ifcOWL, PROV-O, FIBO, DCAT2, ICDD, REC
Materials	Material structures, properties and material batches	ifcOWL, BOT
Occupancy	Occupant behavior, comfort, safety, health; air quality; building acoustics	ifcOWL, BOT, SOSA, REC, Saref
Energy	Energy efficiency including energy systems	ifcOWL, Saref
Lifecycle	Information over LOD levels and construction lifecycle	ifcOWL, Org

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BIM4EEB Conclusion1: toolkit validated and available for further developments

Phase 1



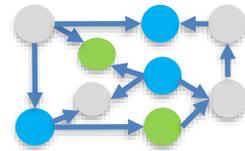
Construction & service companies



HVAC designers



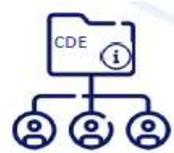
owners & inhabitants



linked data & ontologies

**Requirements,
linked data & ontologies**

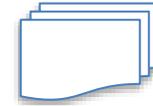
Phase 2



common data environment



AR for fast mapping & survey



Logbook for fast planning & tracking

BIM-BACS data exchange



Tools development

Phase 3



Monza demo site (IT)



Chorzow demo site (PL)



Tampere demo site (FI)

Demonstration in relevant environment

Conclusion2: Digital Twin for energy buildings' renovation based on new ontologies and linked data

- **BIM4EEB toolkit and ontologies are available for sharing, standardization further developments**
- **Digital Twin developments is ongoing: need for an agreed definition and finalization**
- **Dynamic Digital Logbook is one priority for existing building**
- **Need for an International and European Coordination Action to share Sister Projects results and to finalize them for:**
 - **Standardization (ex. CEN TC 442)**
 - **Buildingsmart, W3C**
 - **Building Digital Twin Association**
 - **DIGIPLACE**





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Thank you for your attention!....



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Solintel

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Innovation Energy Research Centre

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PROCHEM



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