CitA
BIM GATHERING

Development of a Model View Definition (MVD) for Thermal Comfort analyses in Commercial Buildings using BIM and EnergyPlus

CitA BIM Gathering 2017, Croke Park, November 23rd & 24th, 2017

وزارة التعليم
Ministry of Education
الملحقية الثقافية السعودية في دبلن
Saudi Cultural Bureau in Dublin

UCD DUBLIN

ENERGY INSTITUTE UCD

Layout

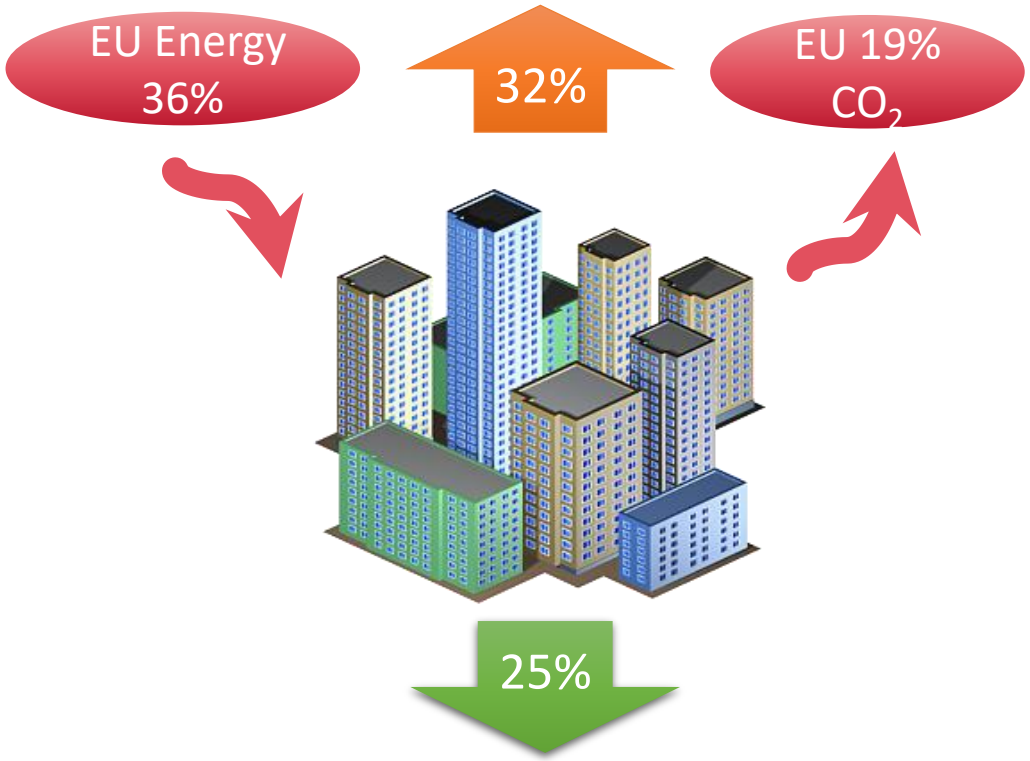
1. Introduction
2. Standardised Methods
3. Methodology
4. Demonstration and Results
5. Conclusion and Future Work

CitA
BIM GATHERING

1. Introduction

Buildings don't operate as intended, with poor prediction as a key factor

Up to 32% of global energy use



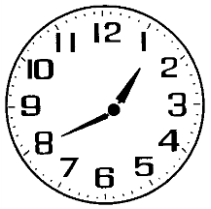
EU aim to achieve 25% reduction in energy use by 2050

Source : EU Climate Action, 2016

- 80% of the energy used in commercial office spaces, is typically used for maintaining optimal comfort levels (heating, cooling, ventilating, and lighting).

Source : SEAI,2015

The buildings where we spend our time, have a significant impact on our health, comfort and wellbeing

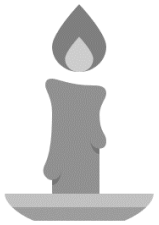


80 -90 %

Of our time in indoor environment.

£13Bil./year

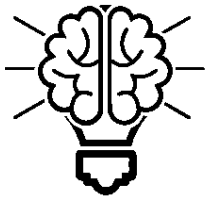
Consumes by the UK employees to control their environment



70,000

Deaths in Europe during the heat wave of August 2003.

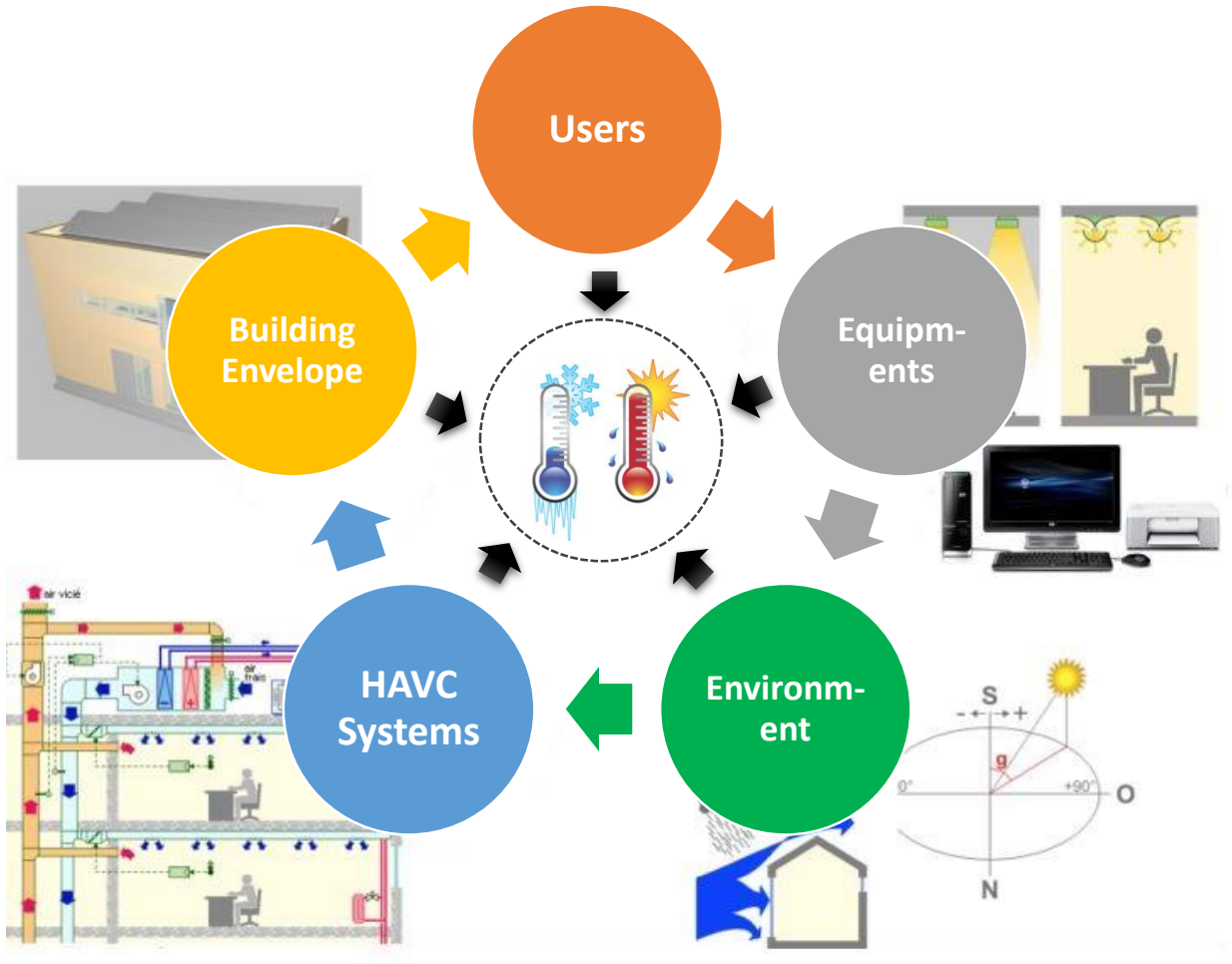
Productivity



Workers tended to lose their productivity during work hours under uncomfortable condition

(ASHRAE) **define thermal comfort** as *"the condition of the mind in which satisfaction is expressed with the thermal environment"*

Demand for low energy & comfortable buildings mandates more complex building design with stringent performance criteria



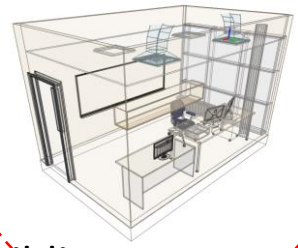
BEPS (Building Energy Performance Simulation)

- Predict the annual **energy performance** of a building .
- Can be used to **predict** differences in energy consumption for different design alternatives.
- Predict the **Thermal comfort level** of a building occupants.
- **Provides** designers with the necessary information about a building design and indoor enverioment

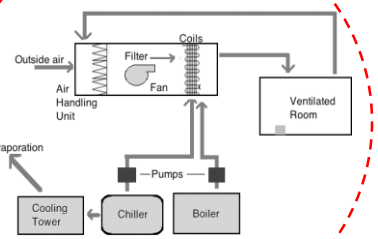
The basic parameters of input data for energy simulation

INPUT DATA

BIM

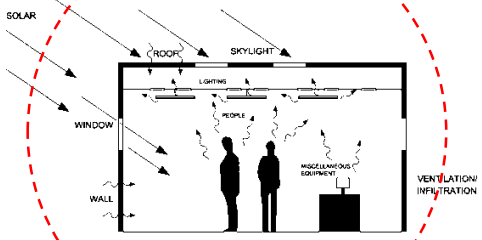


Building geometry



HVAC System

Weather condition

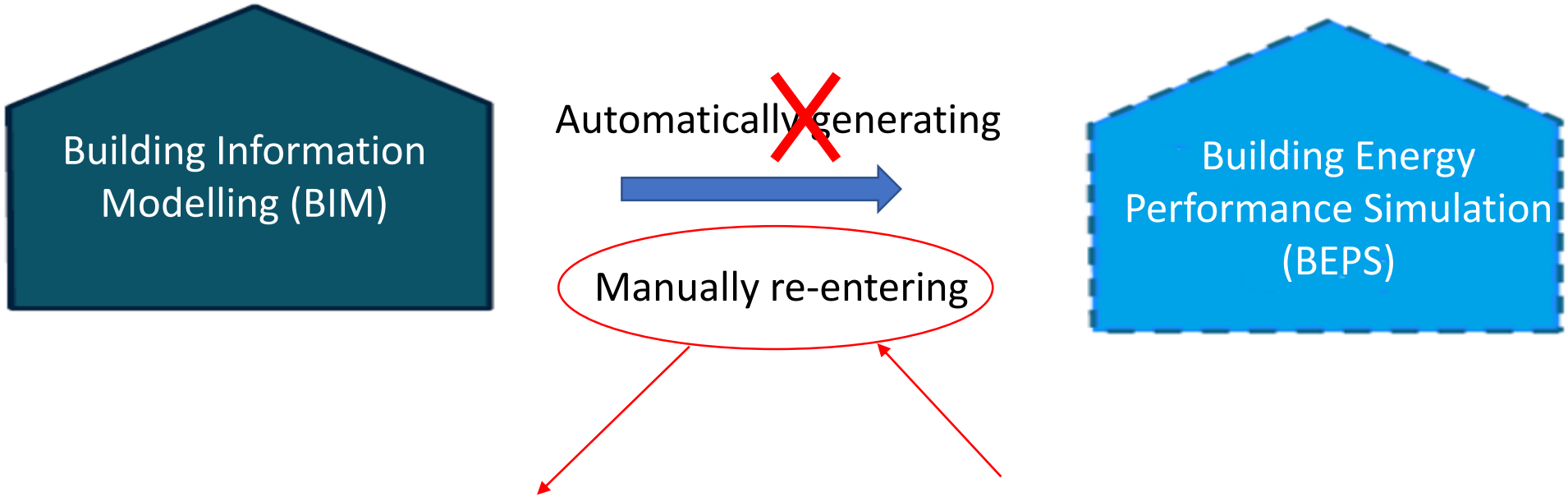


Internal loads

Building Energy Performance Simulation BEPS creation *(e.g. Energy Plus)*

Performance Simulation Results *(e.g. Total Energy Consumption & Thermal Comfort level)*

Problem Statement



Usually resulting in:

- Missing important information
- Misplaced or distorted building elements
- Time consuming and cost of labour.
- Cause inaccuracy of the output.

Still common practice

CitA
BIM GATHERING

2. Standardised Methods

IFC

- **Industry Foundation Classes (IFC)**
  1. Most **commonly used open** and **complete** data format
  2. Objects are represented with **properties and references** to others objects

IDM

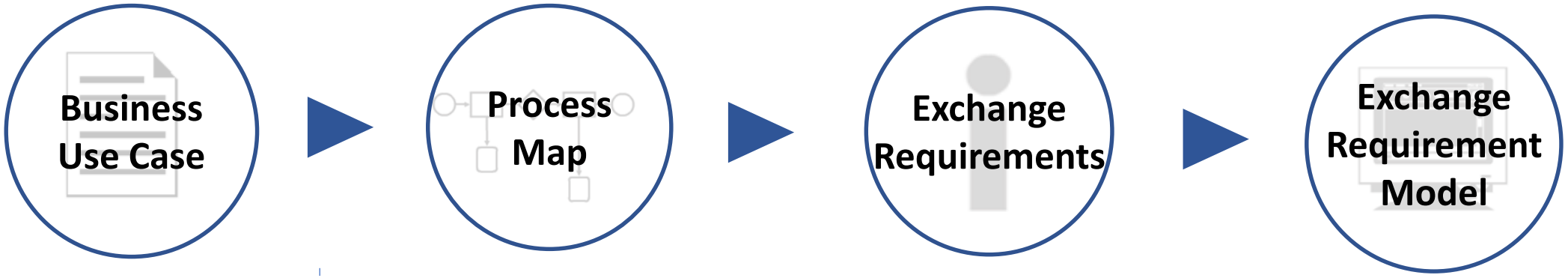
- **Information Delivery Manual (IDM)**
  1. Provides a **standardized method**
  2. **What** information is being exchanged
  3. **Who** needs the information extracted
  4. **Which point in time** this information is needed
  5. Provides a **graphical representation** of the exchange process

MVD

- **Model View Definition (MVD)**
  1. Definition of a **subset of IFC** that satisfies a specific exchange scenario (e.g. Thermal comfort)

Standardised methods for the integration of BIM and BEPS and Information Delivery Manual (IDM)

IDM components



1. Description of the analysis process

2. Graphic translation of the Data flow among stakeholders

3. Description of the information to be exchanged

4. Technical specification of the Exchange Requirement (needed to develop a MVD).

Research Tasks

1. BIM IFC creation model In order to define the process map and the exchange requirements

2. Define the process responsible actors and the data flow between the design stakeholders

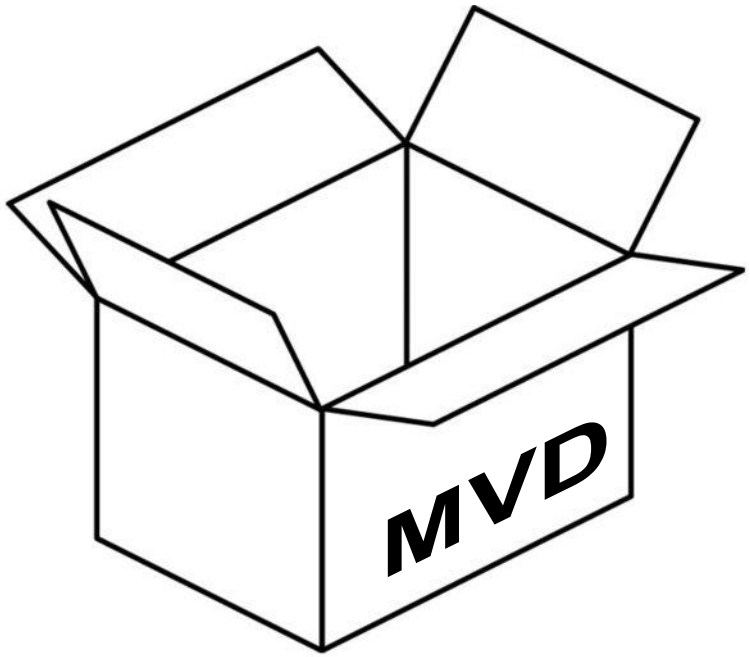
3. Provides a description of the information that support thermal comfort analysis in non-technical terms.

4.Identifying entities and property sets in the existing IFC4 schema that support thermal comfort analysis.

Our MVD

- Aims to be **a unique container** able to collect those pieces of information needed for **Thermal comfort analysis** across the different project stages.
- The output of IFC files includes only the exchange requirements defined for that specific analysis, thus filtering unrelated information.

IFC BIM model
(ISO16739:2013)



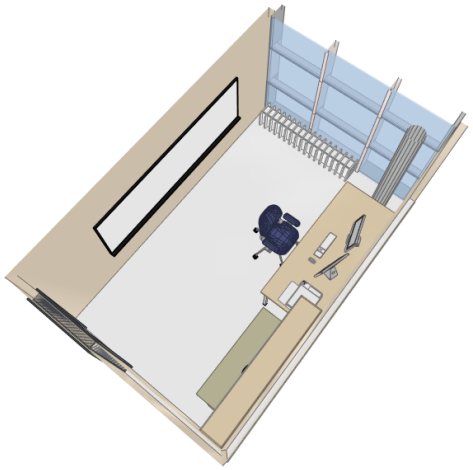
- Standard, open and reusable **data structure**, based on the **IFC** schema.
- Can be delivered in **electronic format** (.ifc, .ifcxml, .xml)
- It represents a subset of the entire IFC data set.

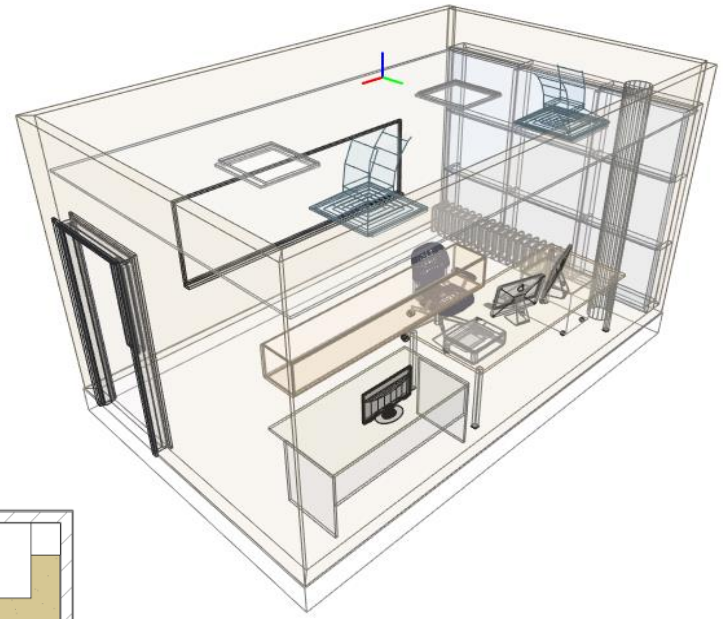
CitA
BIM GATHERING

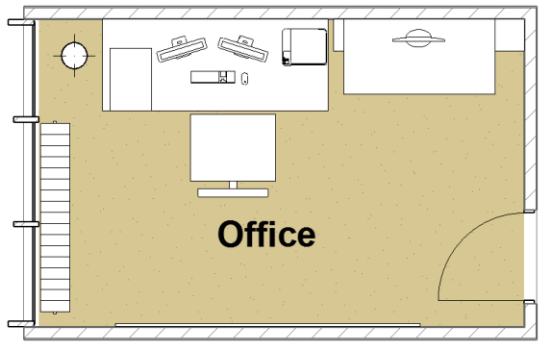
3. Methodology

Task 1: BIM creation

- This office is one of the typical offices located in the School of Mechanical & Materials Engineering, University College Dublin (UCD).
- This use case consists of a single thermal zone and full description for building elements and their properties including HVAC system.

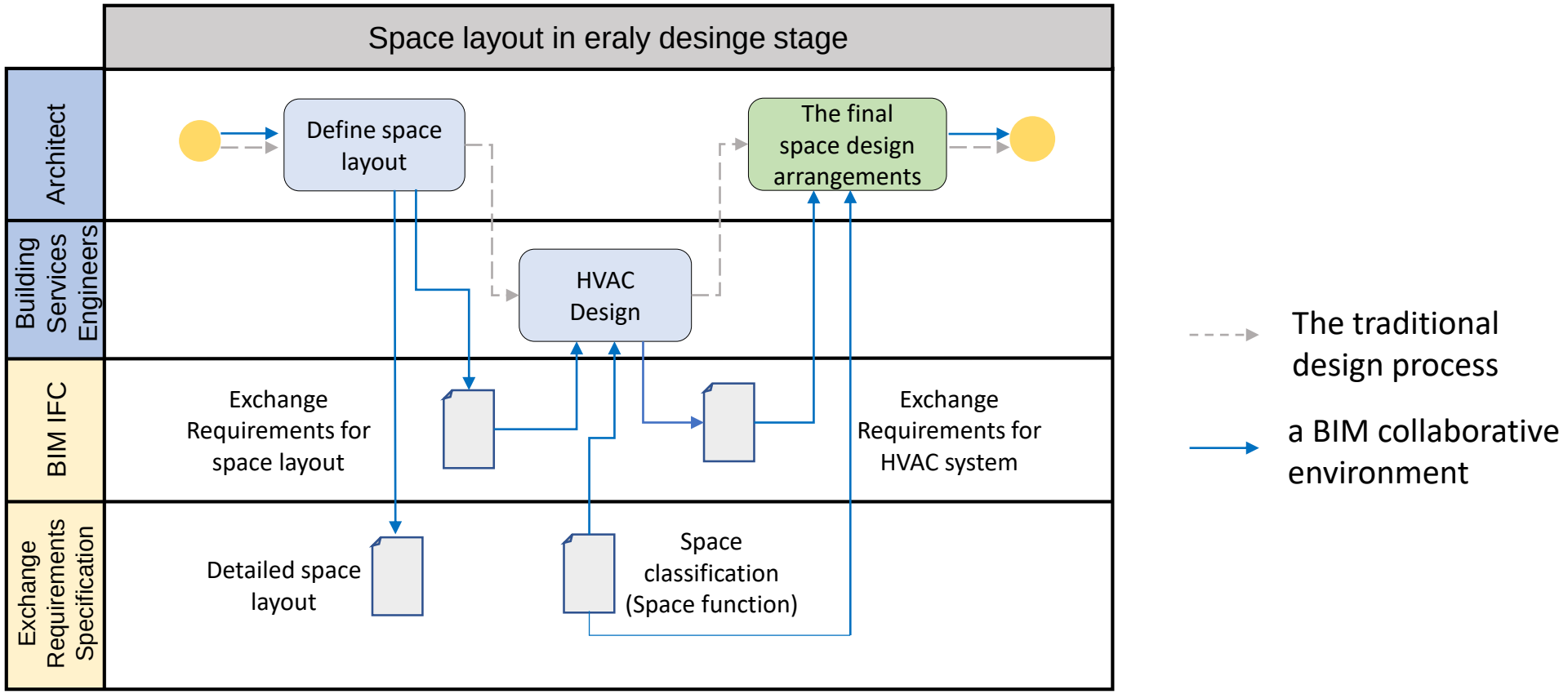






2. Define data exchange mapping process

Task 2: Process Map of information exchange among design team



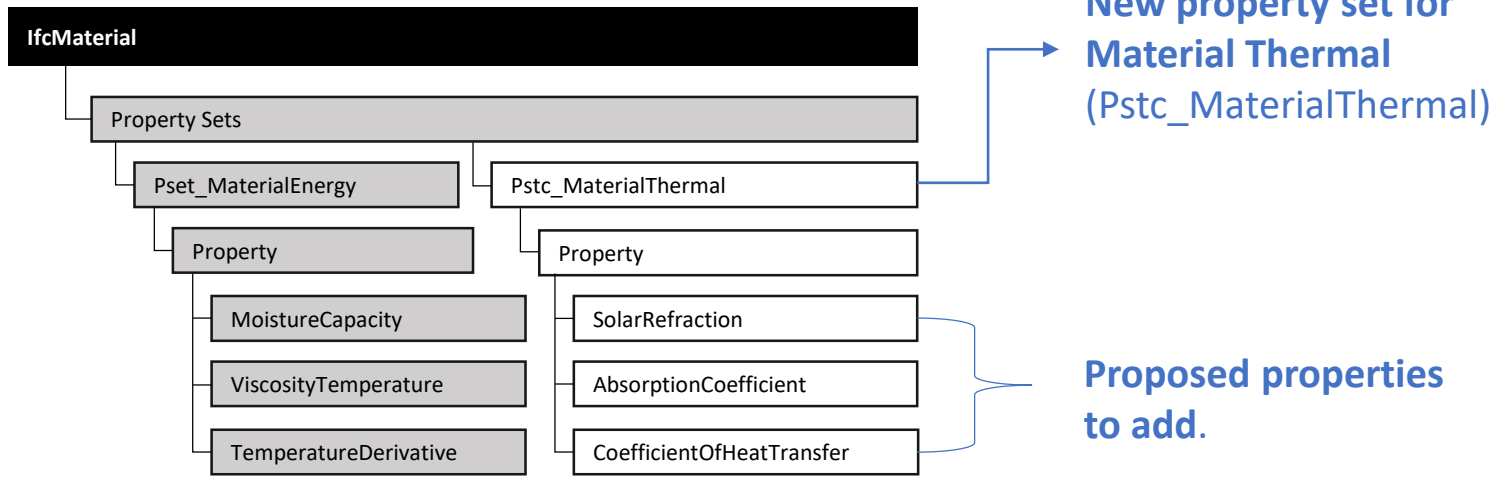
Task 3.1: Provides a description of the information that support thermal comfort analysis in non-technical terms .

- A set of information that needs to be exchanged between processes
- They are general statements of requirement
- They are not specific to an IFC release.

Task 3.2: Identifying entities and property sets in the existing IFC4 schema that support thermal comfort analysis.

Entity	Property Set	Property	Data Type	Unit
IfcSpace	Pset_SpaceOccupancyRequirements	OccupancyType	IfcLabel	--
		OccupancyNumber	IfcCountMeasure	--
		OccupancyNumberPeak	IfcCountMeasure	--
		OccupancyTimePerDay	IfcTimeMeasure	--
		AreaPerOccupant	IfcAreaMeasure	m²
		MinimumHeadroom	IfcLengthMeasure	mm
	Pset_SpaceThermalLoad	People	IfcPowerMeasure	W
		EquipmentSensible	IfcPowerMeasure	W
		Lighting	IfcPowerMeasure	W
		AirExchangeRate	IfcPowerMeasure	W
		DryBulbTemperature	IfcPowerMeasure	W
		RelativeHumidity	IfcPowerMeasure	W
		TotalSensibleLoad	IfcPowerMeasure	W
		InfiltrationSensible	IfcPowerMeasure	W

Task 3.3: Identifying any missing entities or property from the IFC schema that support thermal comfort analysis.

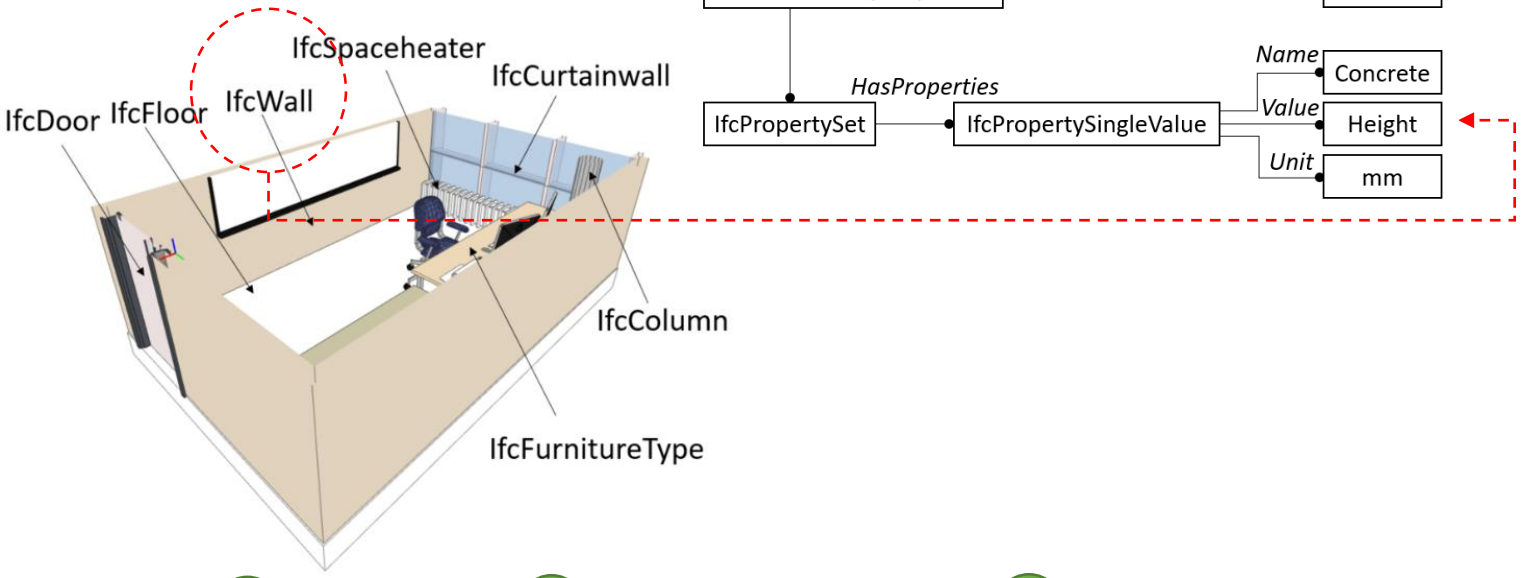


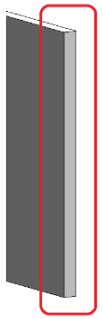
Exiting entity in IFC4

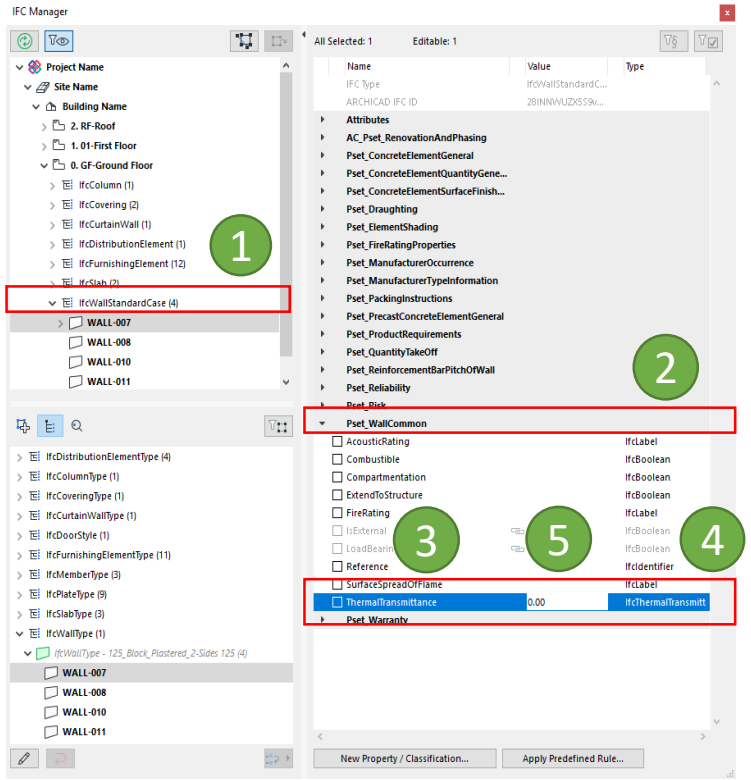
Exiting properties in IFC4

Proposed properties to add

Task 3.4: Define the Exchange Requirements needed to develop MVD for Thermal comfort analysis



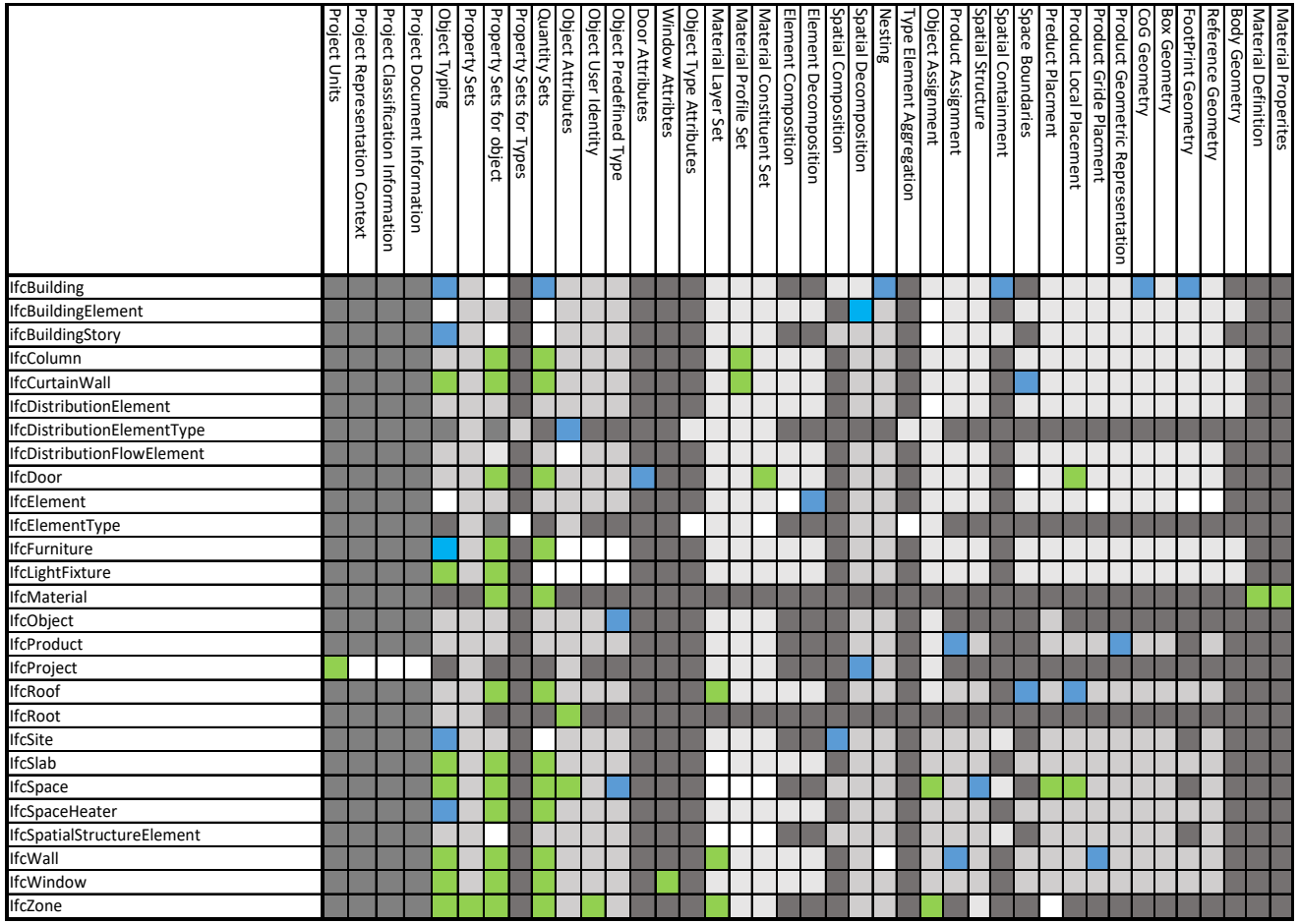




1 Entity	2 Property Set	3 Property	4 Data Type	5 Unit
IfcWall	Pset_WallCommon	ThermalTransmittance	ThermalTransmittanceMeasure	W/m².K

Task 4: Create data extraction (MVD) for Thermal Comfort analysis

- IfcDoc improve the consistent and computer-interpretable definition of (MVD) as true subsets of the IFC Specification.
- To date this work has identified 11 objects.
- Over 109 properties relevant for thermal comfort analysis.



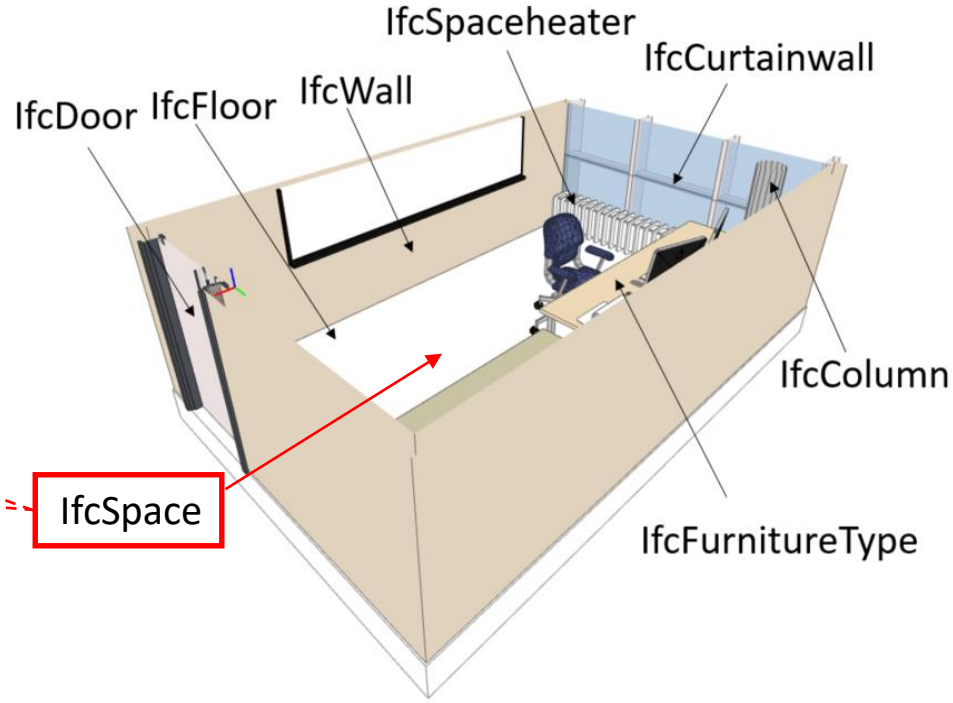
- Set as mandatory for export function
- Set as optional for export function
- Incompatible
- Not relevant but has been defined
- Within scope but not defined

CitA
BIM GATHERING

4. Demonstration

With use cases that enable control over the export to IFC we specified the necessary information exchange

Entity	Property Set	Property	Data Type	Unit
IfcSpace	Pset_ SpaceOccupancyRequirements	OccupancyType	IfcLabel	--
		OccupancyNumber	IfcCountMeasure	--
		OccupancyNumberPeak	IfcCountMeasure	--
		OccupancyTimePerDay	IfcTimeMeasure	--
		AreaPerOccupant	IfcAreaMeasure	m²/p
		MinimumHeadroom	IfcLengthMeasure	mm
	Pset_ SpaceThermalLoad	Activity level	IfcPowerMeasure	met
		EquipmentSensible	IfcPowerMeasure	kW
		Lighting	IfcPowerMeasure	kW
		AirExchangeRate	IfcPowerMeasure	m³/s
		DryBulbTemperature	IfcPowerMeasure	°C
		RelativeHumidity	IfcPowerMeasure	%
		TotalSensibleLoad	IfcPowerMeasure	W
		InfiltrationSensible	IfcPowerMeasure	W



- IfcSpace where the most properties for thermal comfort were defined.

CitA
BIM GATHERING

5. Conclusion & Future Work

Conclusion

- Providing thermal comfort for a building's occupants remains one of the main aims of designing and creating a working or living space.

- Thermal comfort simulation analysis requires detailed specification of the data and information that needs to be exchanged to support these processes.

- The outputs of this work will contribute to:

1. Data to be transferred in a higher level of automation
2. Less manual work, lower risk of human error and better information quality
3. Achieve optimum and reliable results of thermal comfort analysis
4. Reduce cost and labour intensive as well as complexity.

Future Work

- The next part of this research will focus on extend this methodology to account for CFD modelling based simulations of thermal comfort.
- Further specification of the MVD to include all relevant building components.
- Extension of the IFC schema for missing concepts, entities and properties.
- The proposed MVD will be applied and tested in a full-scale building.
- Submit the MVD to buildingSMART to become an official MVD.

CitA
BIM GATHERING

Thank you

Fawaz Alshehri

LinkedIn
Fawaz Alshehri

وزارة التعليم
Ministry of Education
الملحقية الثقافية السعودية في دبلن
Saudi Cultural Bureau in Dublin

UCD DUBLIN

ENERGY INSTITUTE UCD