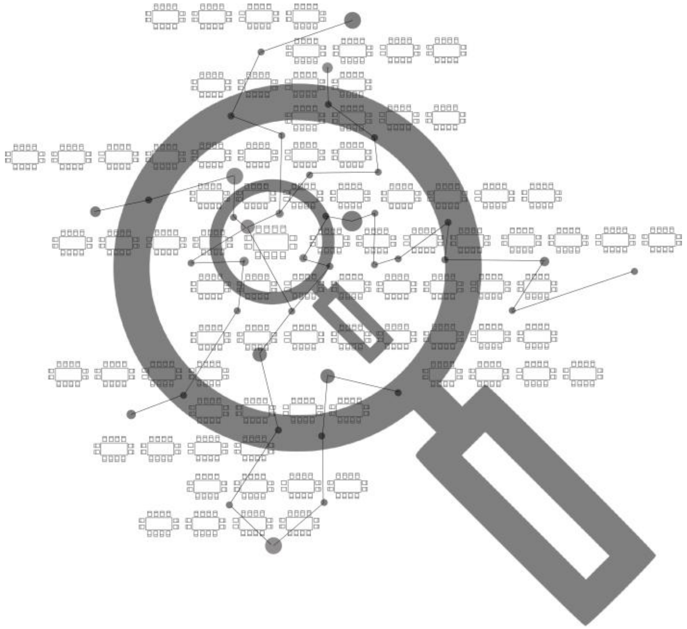
The data-driven workplace

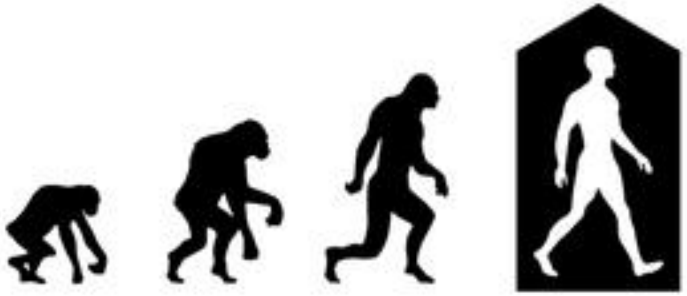
Exploring the application of sensor data for facility managers in an Activity-Based Working environment (ABW)



P5 Presentation
Lezma Sulayman
4421612
26-06-2020

Introduction

Introduction



Source: The Indoor Generation (n.d.)

Introduction

Source: The Indoor Generation (n.d.)

Introduction

Introduction

Source: transitions (n.d.)

Introduction

Activity-Based Working (ABW)

People

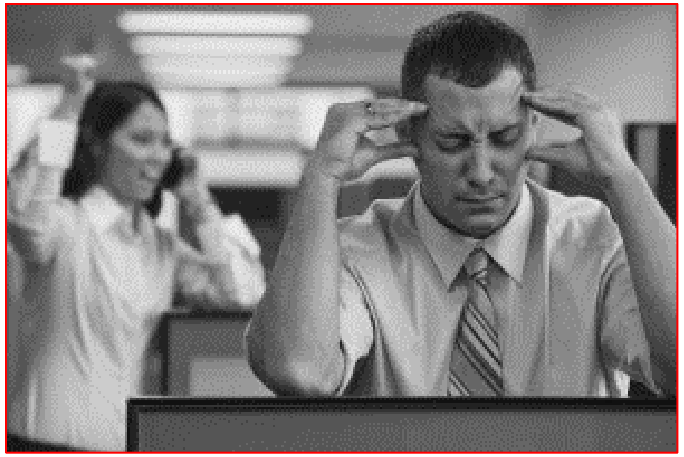
Place

Technology

Introduction

Source: transitions (n.d.)

Introduction



Acoustic privacy

Source: Vollgraaff (2016)

Introduction

Space usage – underutilized

Source: Mapiq (n.d.)

Introduction

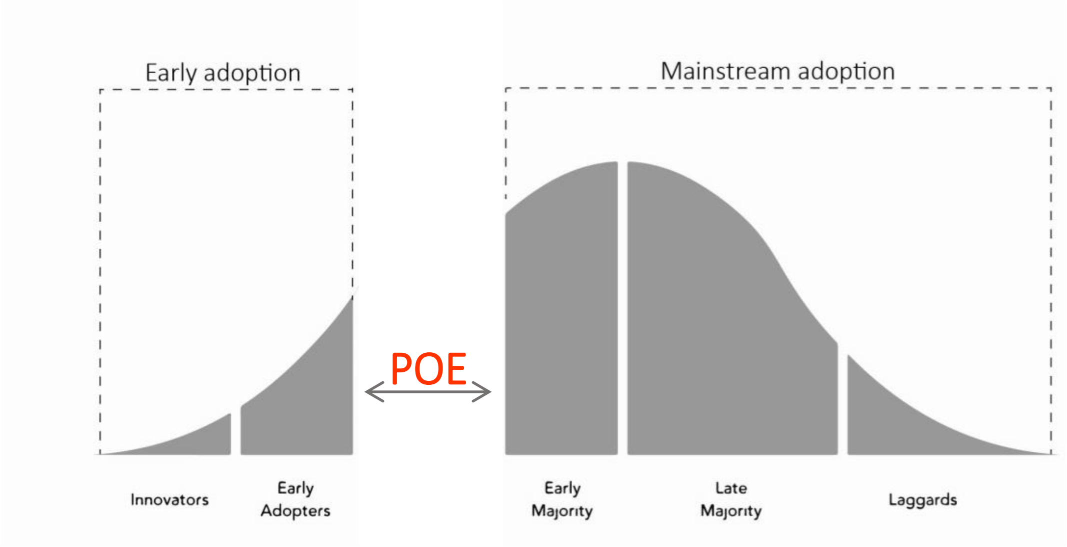
Space usage – overutilized

Source: Mapiq (n.d.)

Introduction

?

Introduction


Early adoption
Mainstream adoption
POE
Innovators
Early Adopters
Early Majority
Late Majority
Laggards

Introduction

Facility manager

Introduction

Workplace environment

Validation of performance

Facility manager

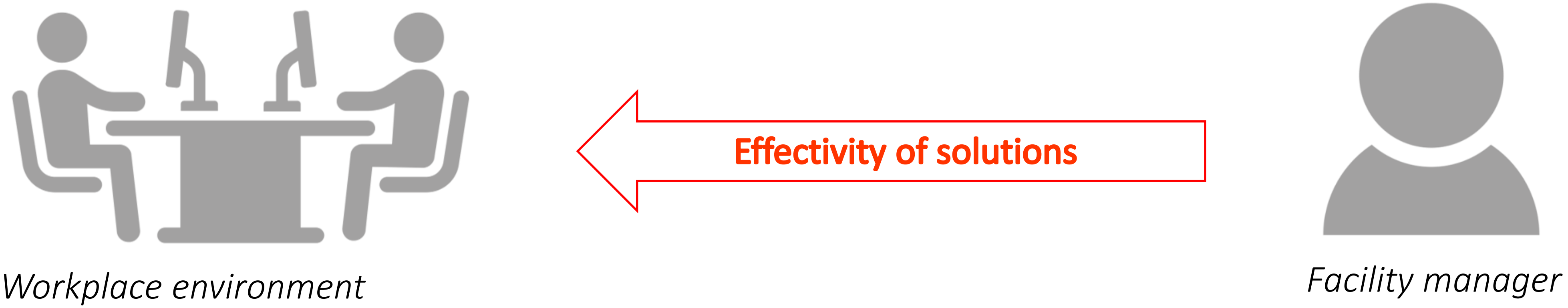
Introduction

Surveys

Introduction

Primary data source

Introduction



Workplace environment

Effectivity of solutions

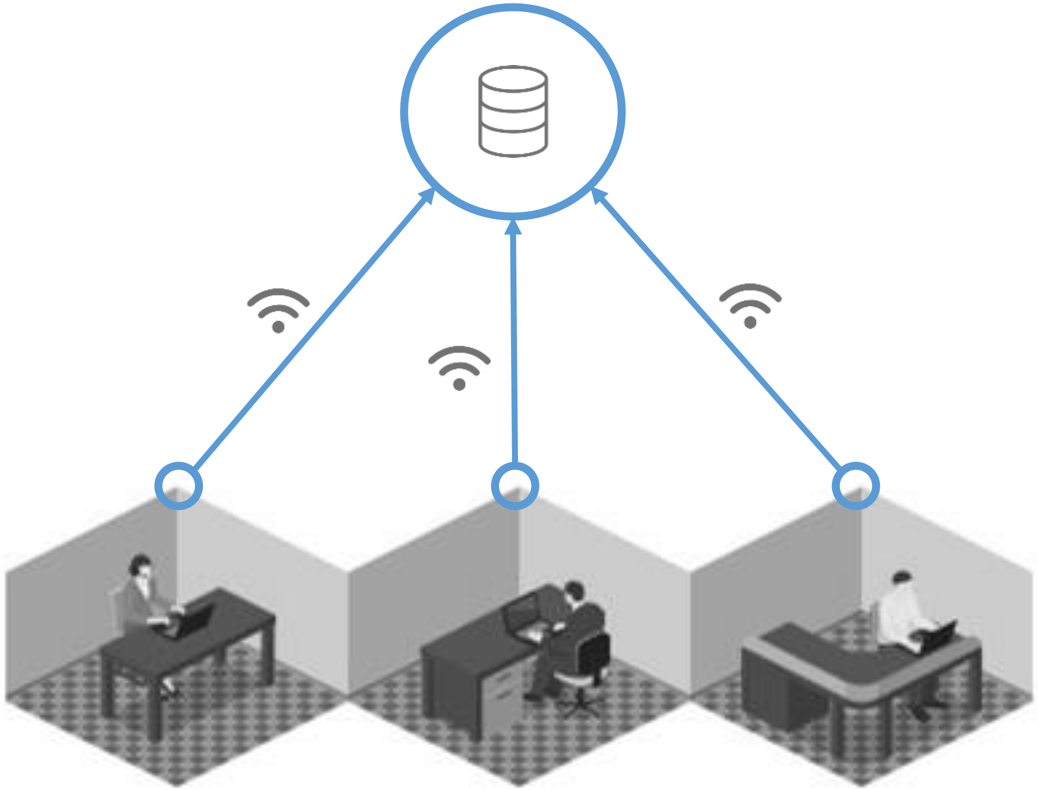
Facility manager

Introduction

Smart buildings

Source: Mindtree (n.d.)

Introduction



Internet of Things (IoT)

Introduction

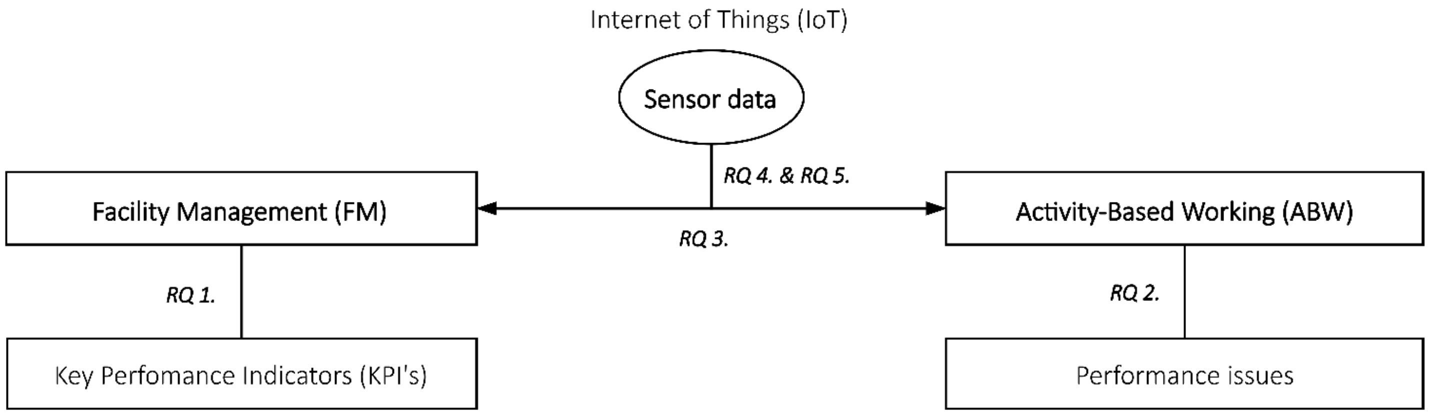
Sensor data

Introduction

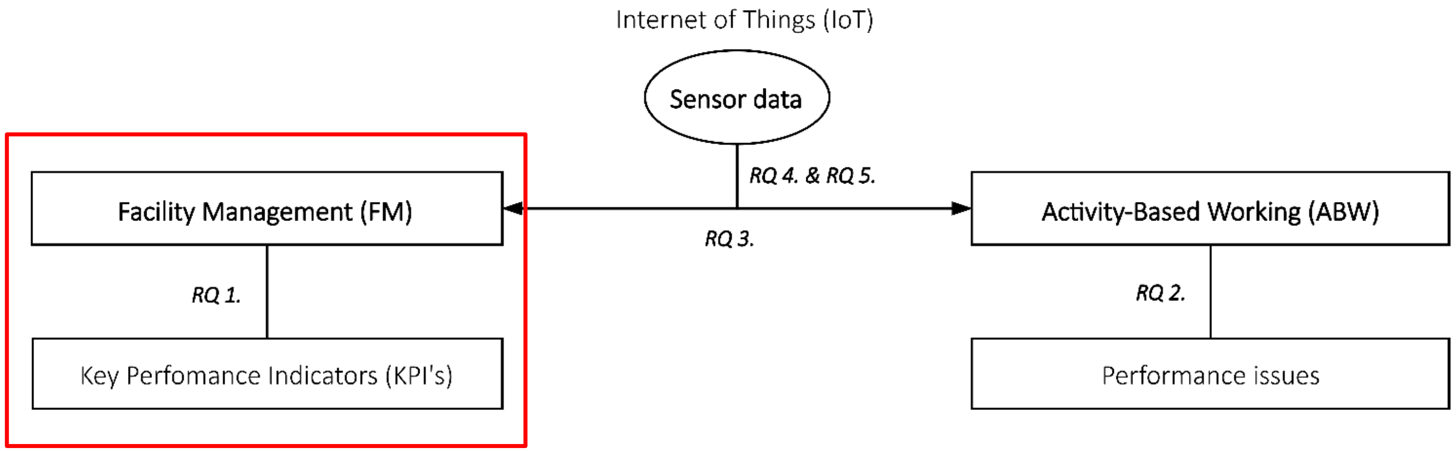
Introduction

Main RQ. How can facility managers validate the performance of the Activity-Based Working (ABW) environment with the application of sensor data in an Internet of Things (IoT)?

Introduction


Internet of Things (IoT)
Sensor data
RQ 4. & RQ 5.
Facility Management (FM)
RQ 3.
Activity-Based Working (ABW)
RQ 1.
RQ 2.
Key Perfomance Indicators (KPI's)
Performance issues

Introduction



Internet of Things (IoT)

Sensor data

RQ 4. & RQ 5.

Facility Management (FM)

RQ 3.

Activity-Based Working (ABW)

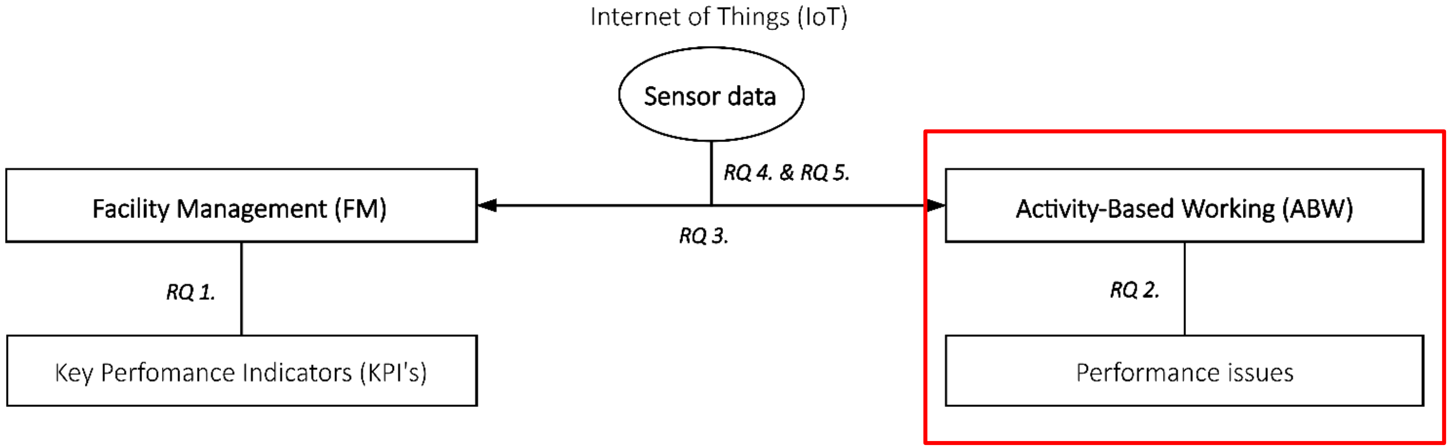
RQ 1.

Key Perfomance Indicators (KPI's)

RQ 2.

Performance issues

Introduction



Internet of Things (IoT)

Sensor data

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Activity-Based Working (ABW)

RQ 1.

RQ 2.

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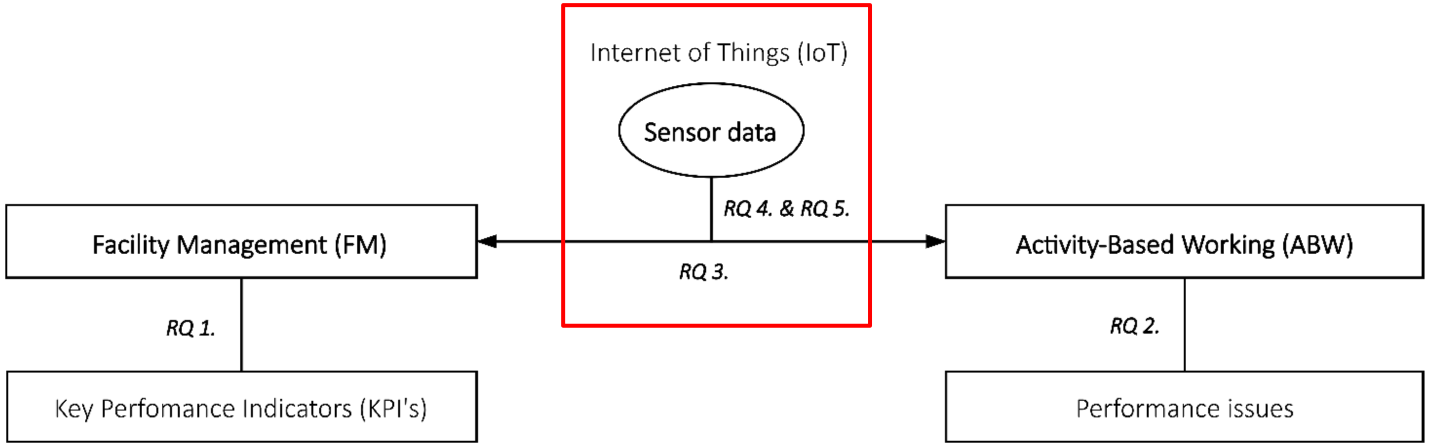
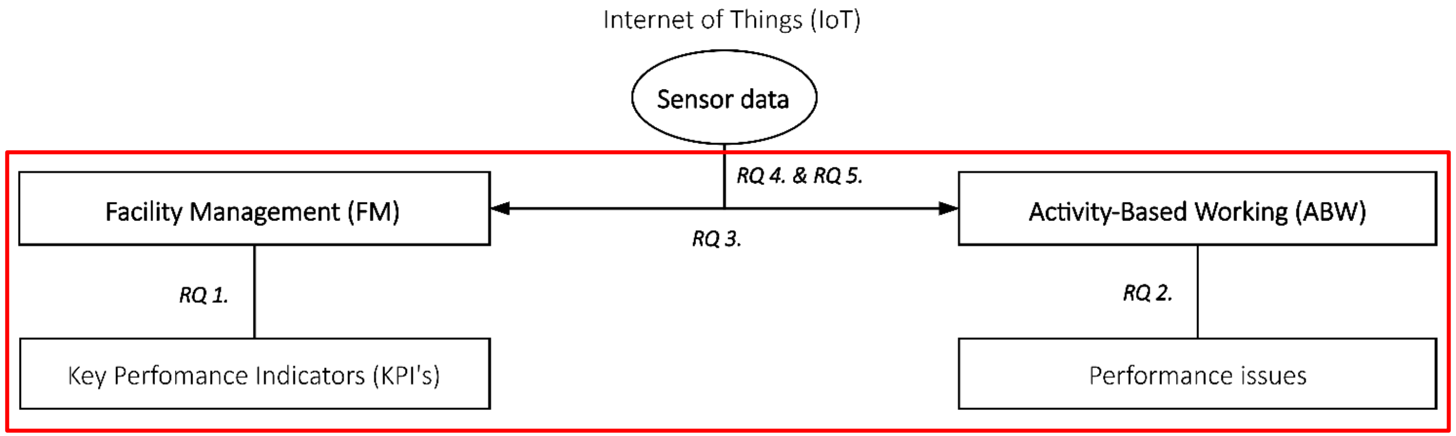
Introduction


Internet of Things (IoT)
Sensor data
RQ 4. & RQ 5.
Facility Management (FM)
RQ 3.
Activity-Based Working (ABW)
RQ 1.
RQ 2.
Key Perfomance Indicators (KPI's)
Performance issues

Theoretical framework

Introduction



Internet of Things (IoT)

Sensor data

RQ 4. & RQ 5.

Facility Management (FM)

Activity-Based Working (ABW)

RQ 3.

RQ 1.

RQ 2.

Key Perfomance Indicators (KPI's)

Performance issues

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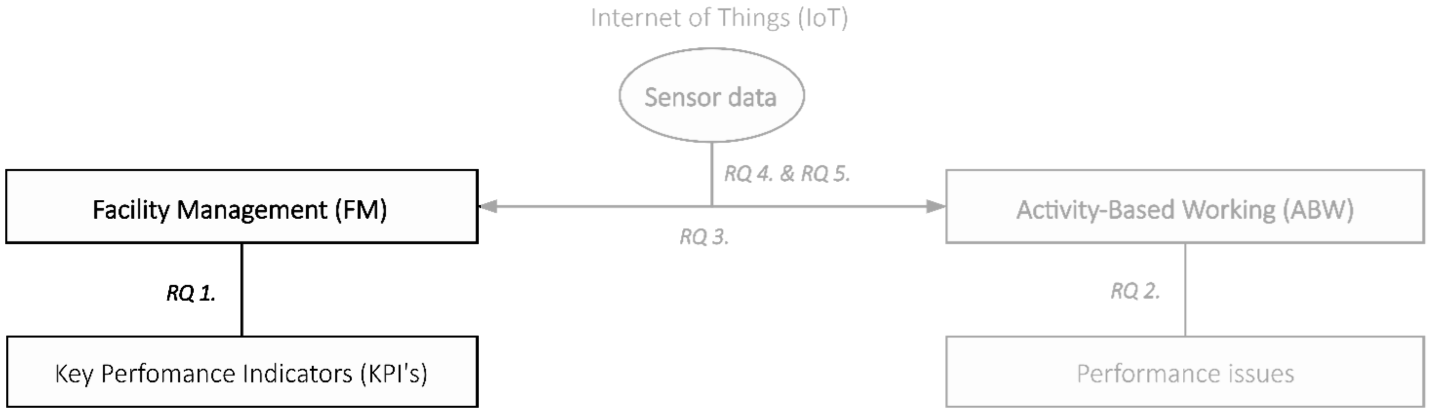
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Sensor data
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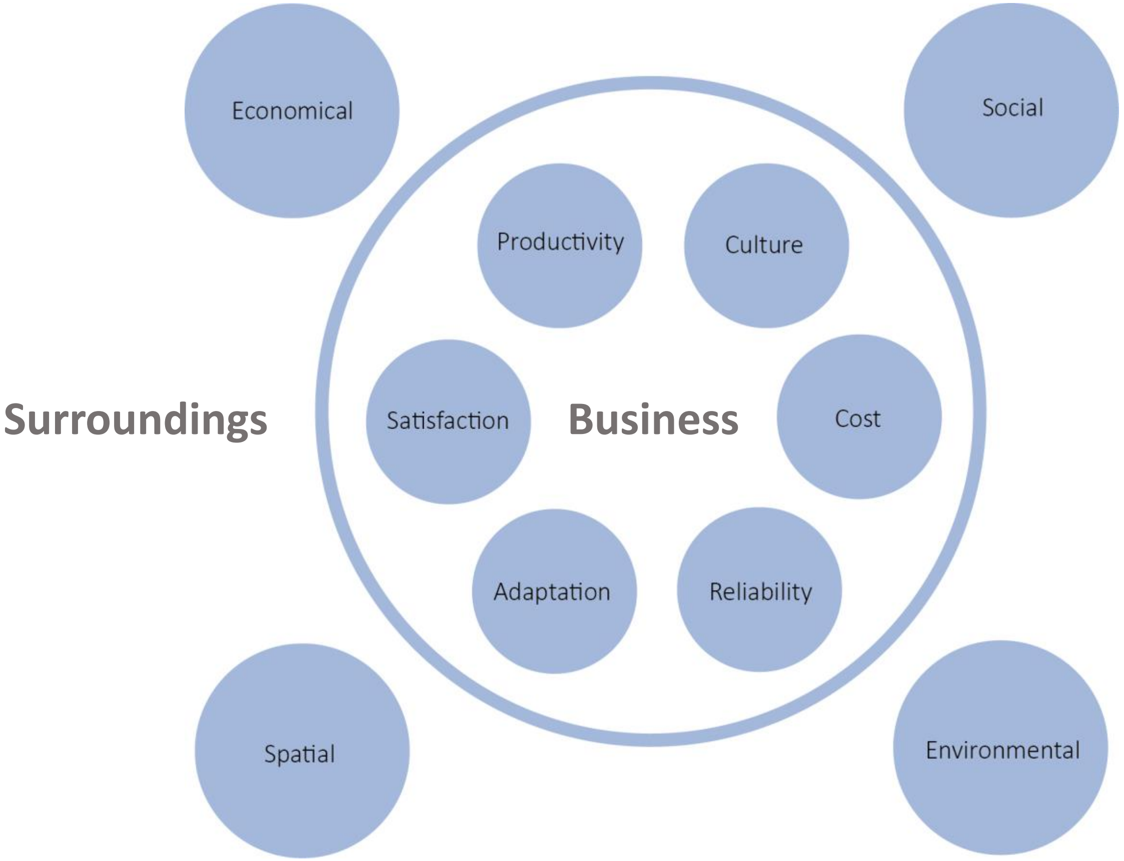
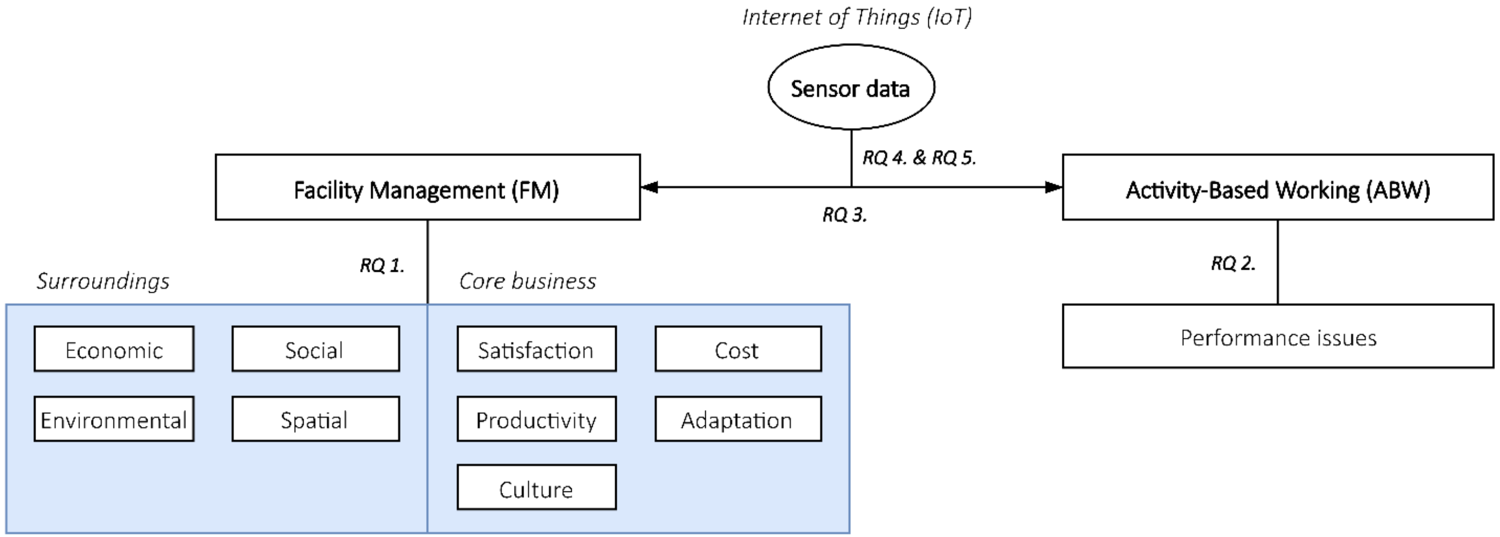
Theoretical framework

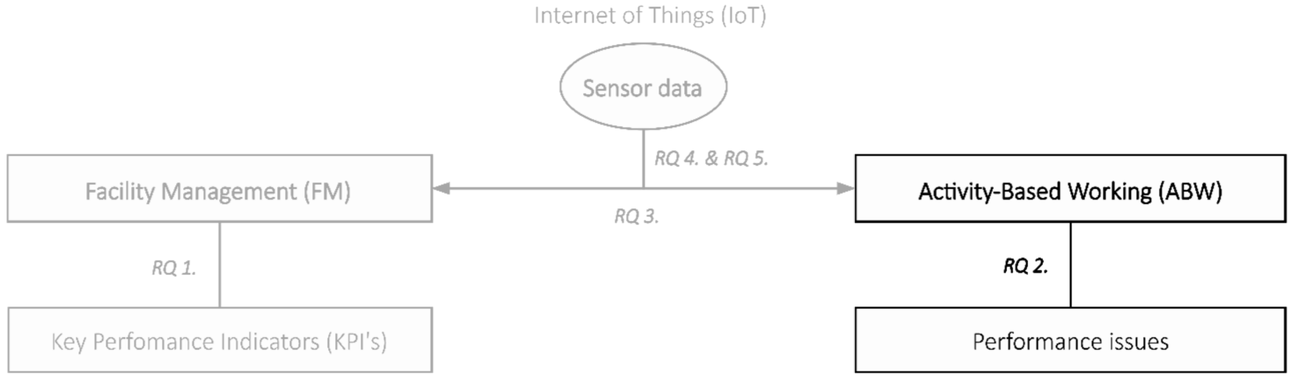
Theoretical framework


Economical
Social
Productivity
Culture
Surroundings
Satisfaction
Business
Cost
Adaptation
Reliability
Spatial
Environmental

Theoretical framework


Internet of Things (IoT)
Sensor data
RQ 4. & RQ 5.
Facility Management (FM)
RQ 3.
Activity-Based Working (ABW)
RQ 1.
Surroundings
Core business
RQ 2.
Economic
Social
Satisfaction
Cost
Performance issues
Environmental
Spatial
Productivity
Adaptation
Culture

Theoretical framework


Internet of Things (IoT)
Sensor data
RQ 4. & RQ 5.
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RQ 2.
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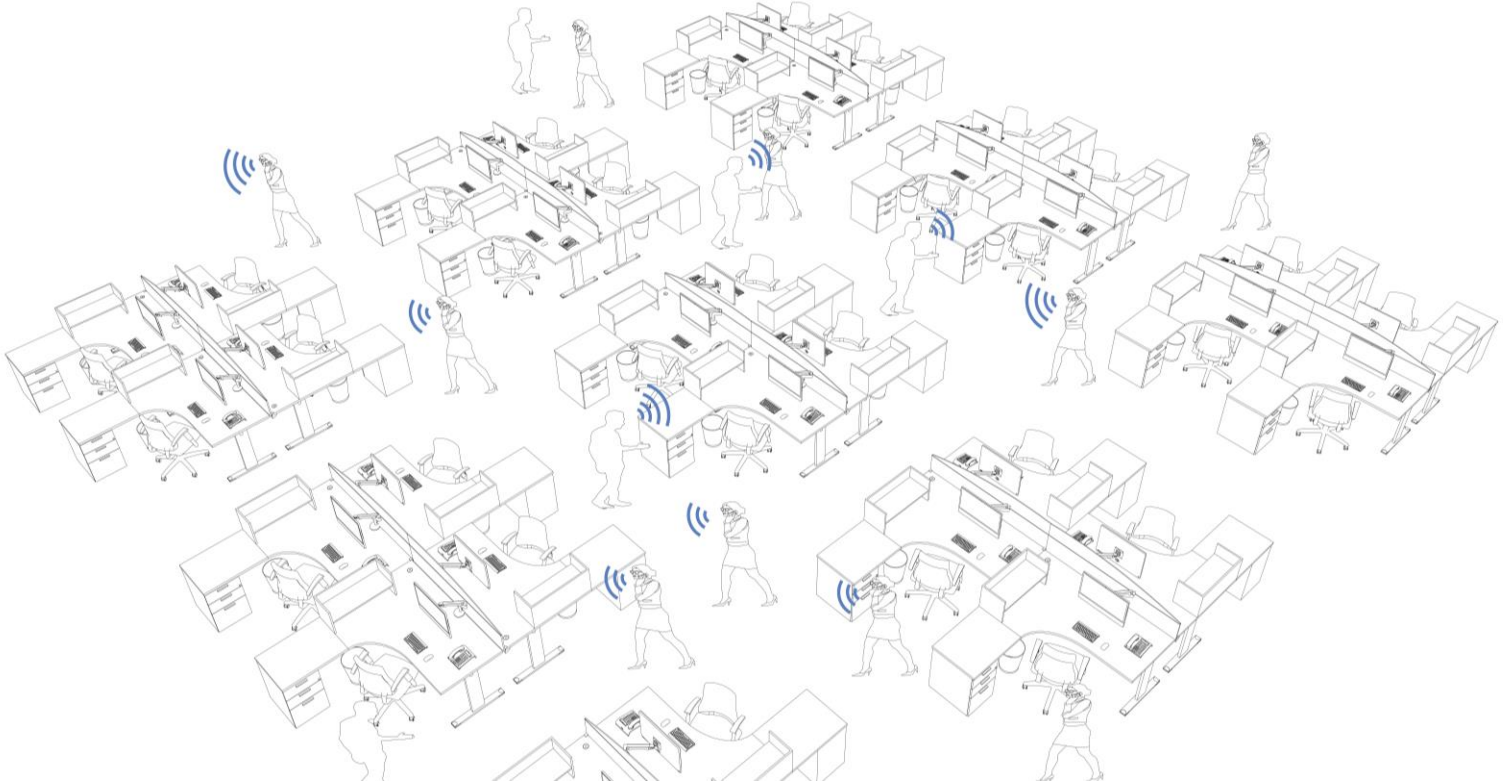
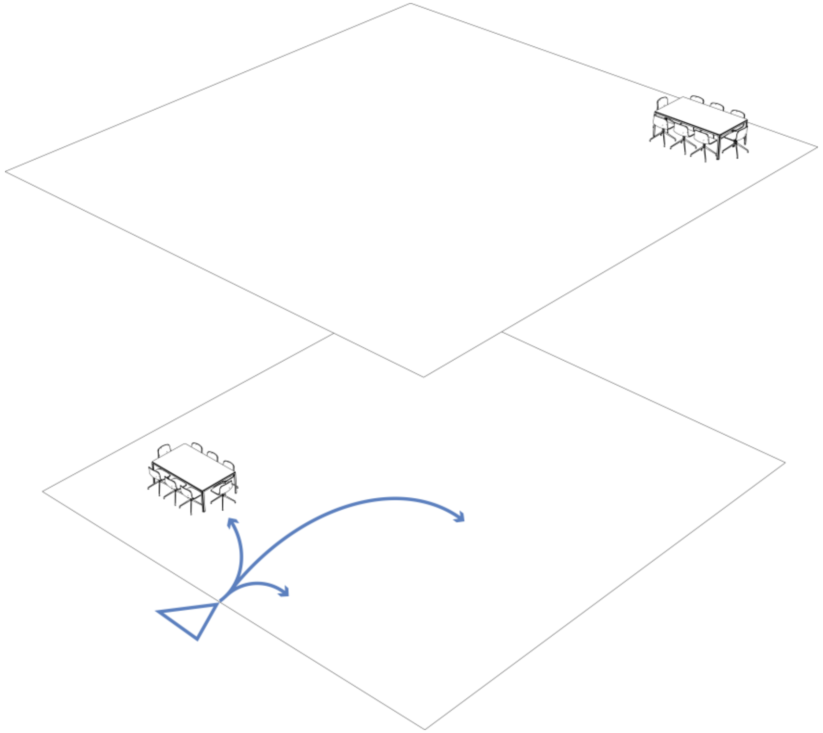
Performance issues

Theoretical framework



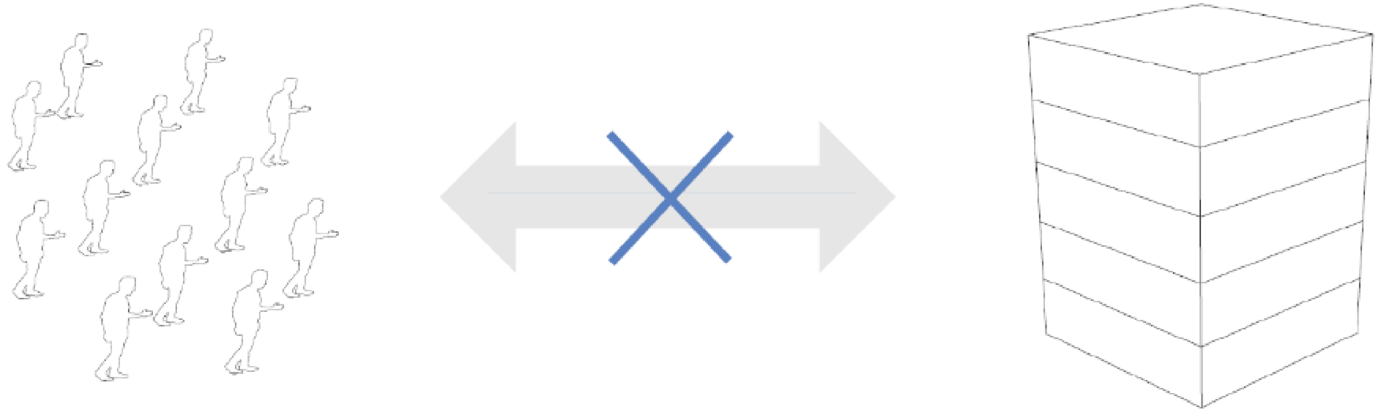
Acoustic privacy

Theoretical framework



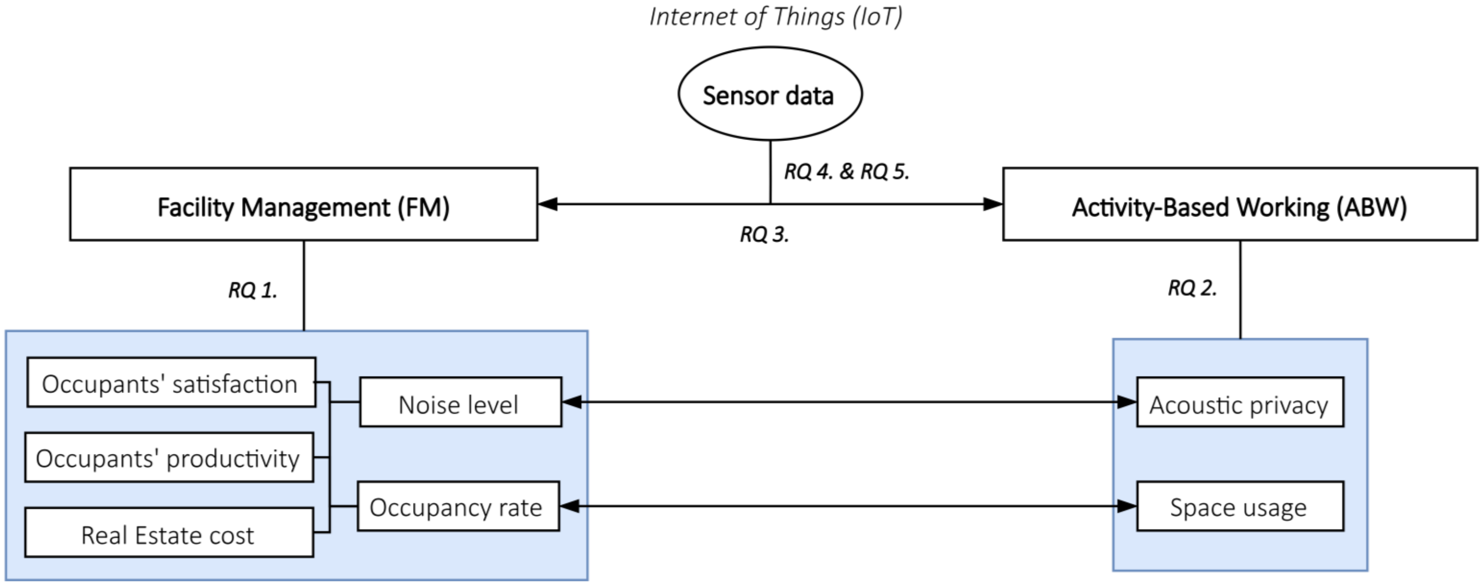
Space usage - Location

Theoretical framework



Space usage - Organization

Theoretical framework



Internet of Things (IoT)

Sensor data

RQ 4. & RQ 5.

Facility Management (FM)

RQ 3.

Activity-Based Working (ABW)

RQ 1.

RQ 2.

Occupants' satisfaction

Occupants' productivity

Real Estate cost

Noise level

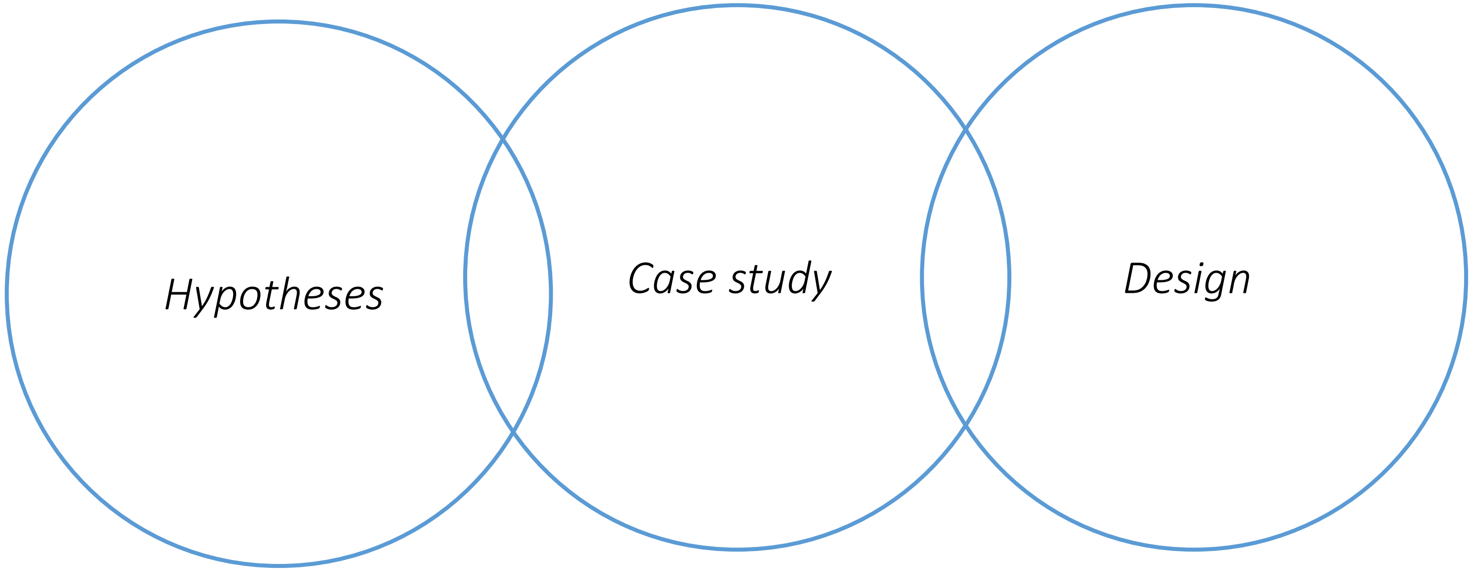
Occupancy rate

Acoustic privacy

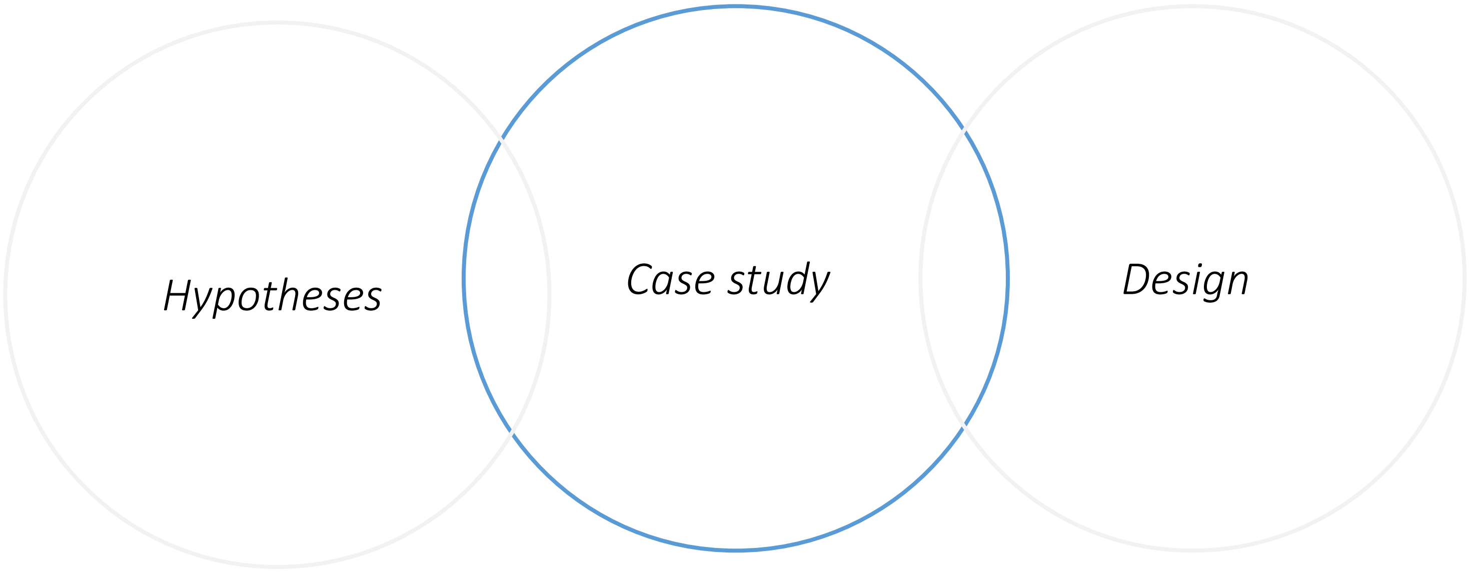
Space usage

Emperical research

Emperical research


Hypotheses
Case study
Design

Emperical research

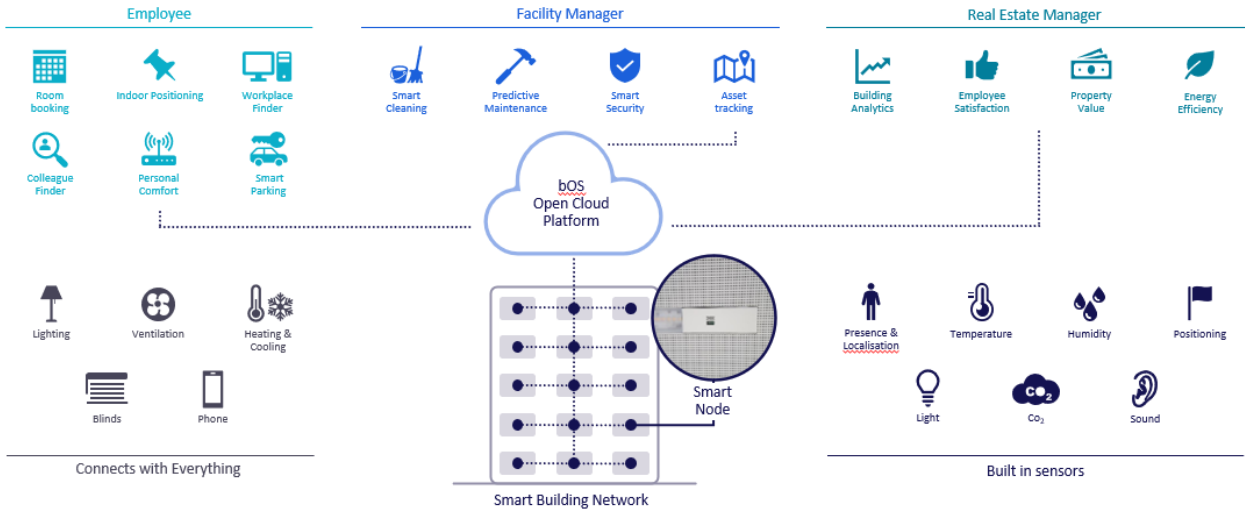


Hypotheses

Case study

Design

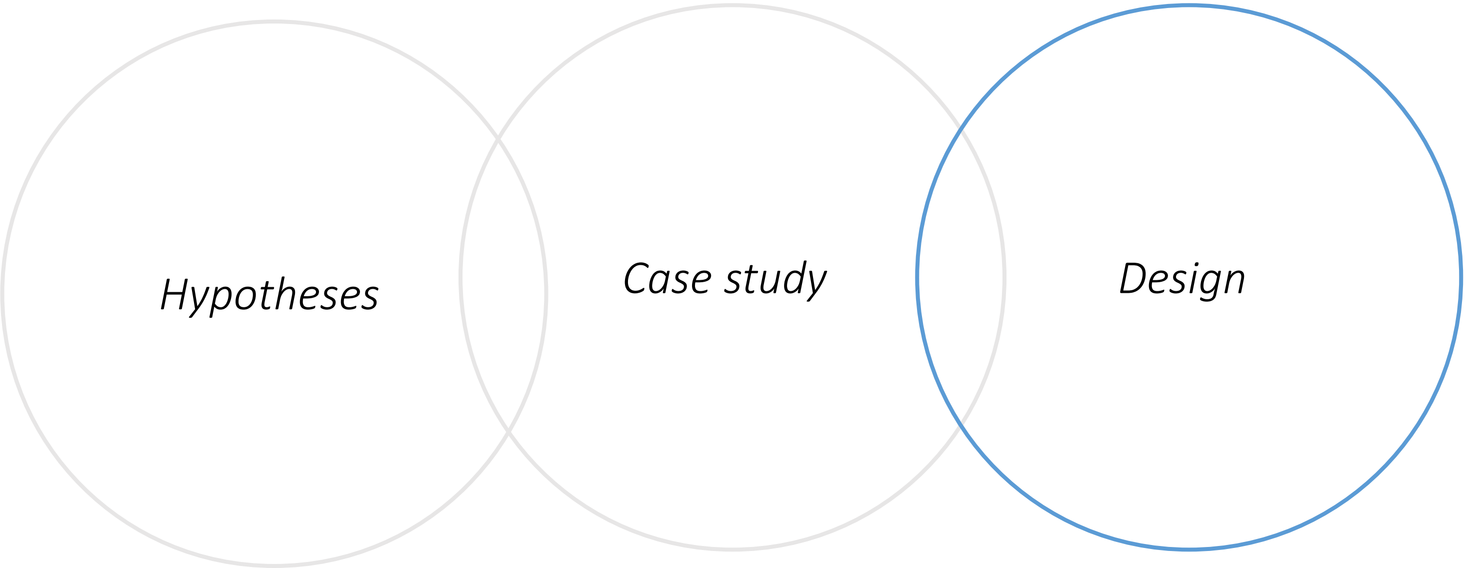
Emperical research


Employee
Room booking
Indoor Positioning
Workplace Finder
Colleague Finder
Personal Comfort
Smart Parking
Facility Manager
Smart Cleaning
Predictive Maintenance
Smart Security
Asset tracking
Real Estate Manager
Building Analytics
Employee Satisfaction
Property Value
Energy Efficiency
bOS
Open Cloud
Platform
Lighting
Ventilation
Heating & Cooling
Blinds
Phone
Connects with Everything
Smart Node
Smart Building Network
Presence & Localisation
Temperature
Humidity
Positioning
Light
Co2
Sound
Built in sensors

Emperical research

Measurement	**Value**
Temperature	Degree Celsius
Humidity	Percentage Humidity
Light intensity	Lux
CO2	Parts Per Million (PPM)
Movement	Pulse per minute
Noise level	Millivolt (MV)
Presence	0 = “available” - 1 = “occupied”

Emperical research

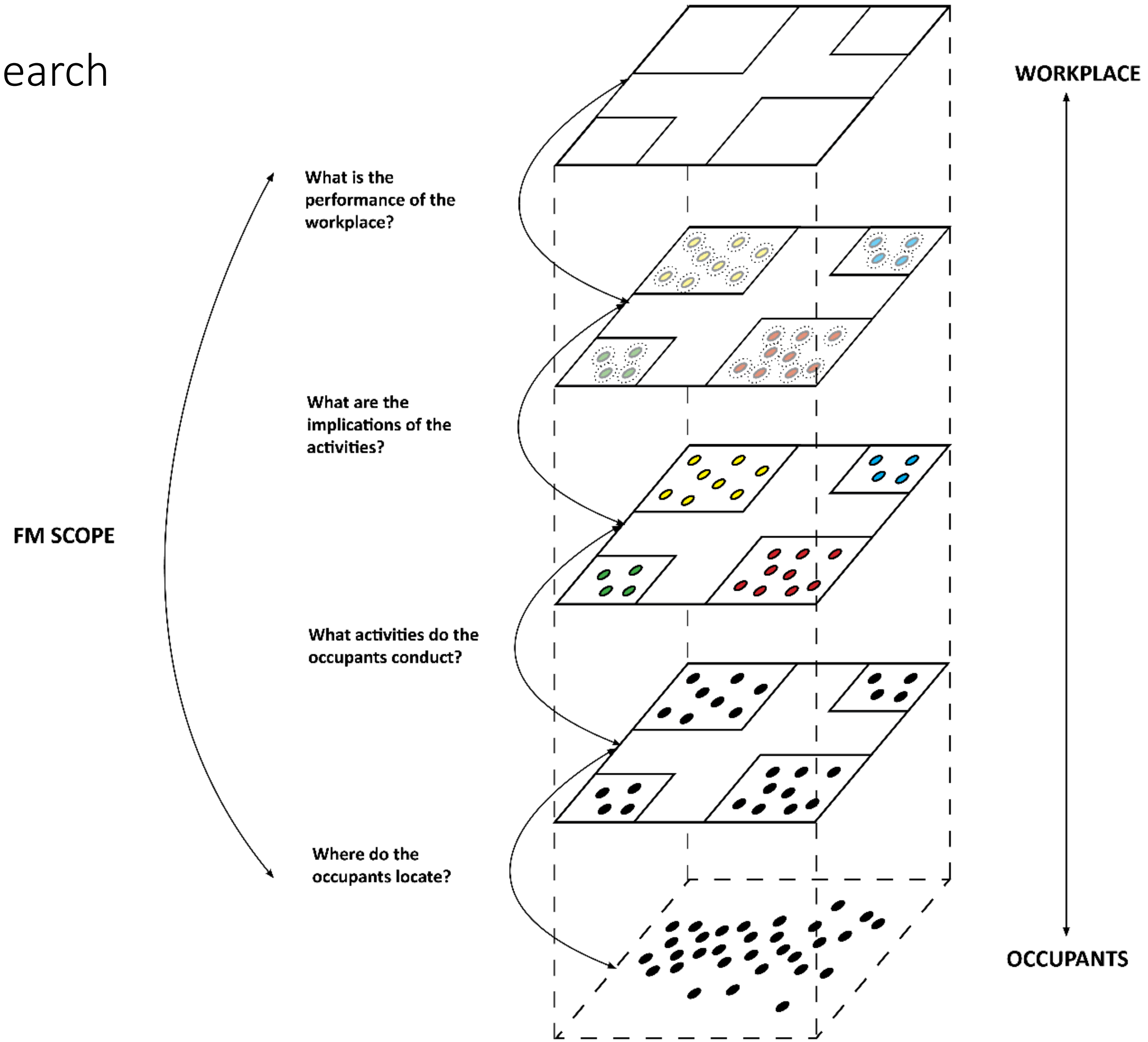


Hypotheses

Case study

Design

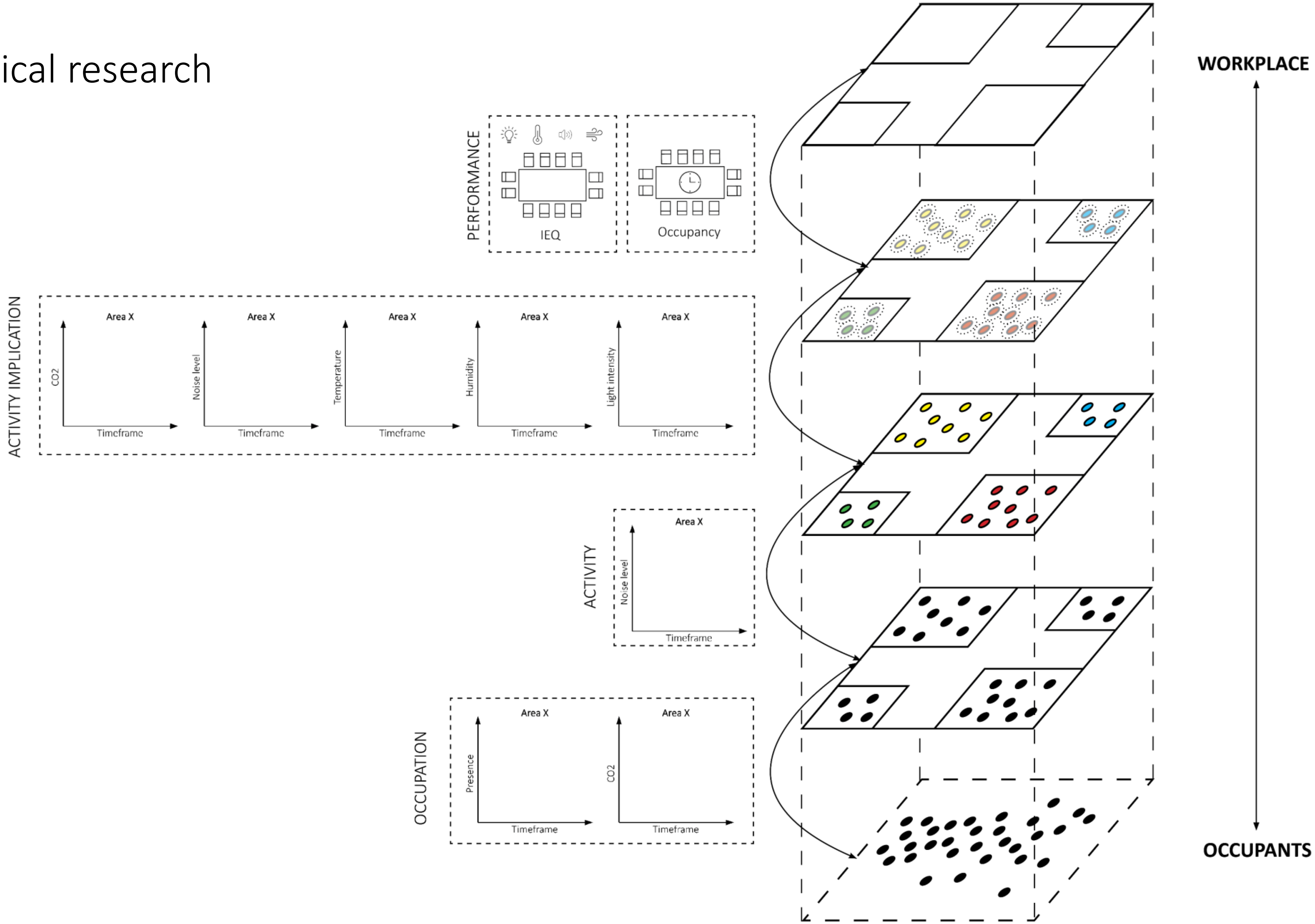
Emperical research


WORKPLACE
What is the performance of the workplace?
What are the implications of the activities?
FM SCOPE
What activities do the occupants conduct?
Where do the occupants locate?
OCCUPANTS

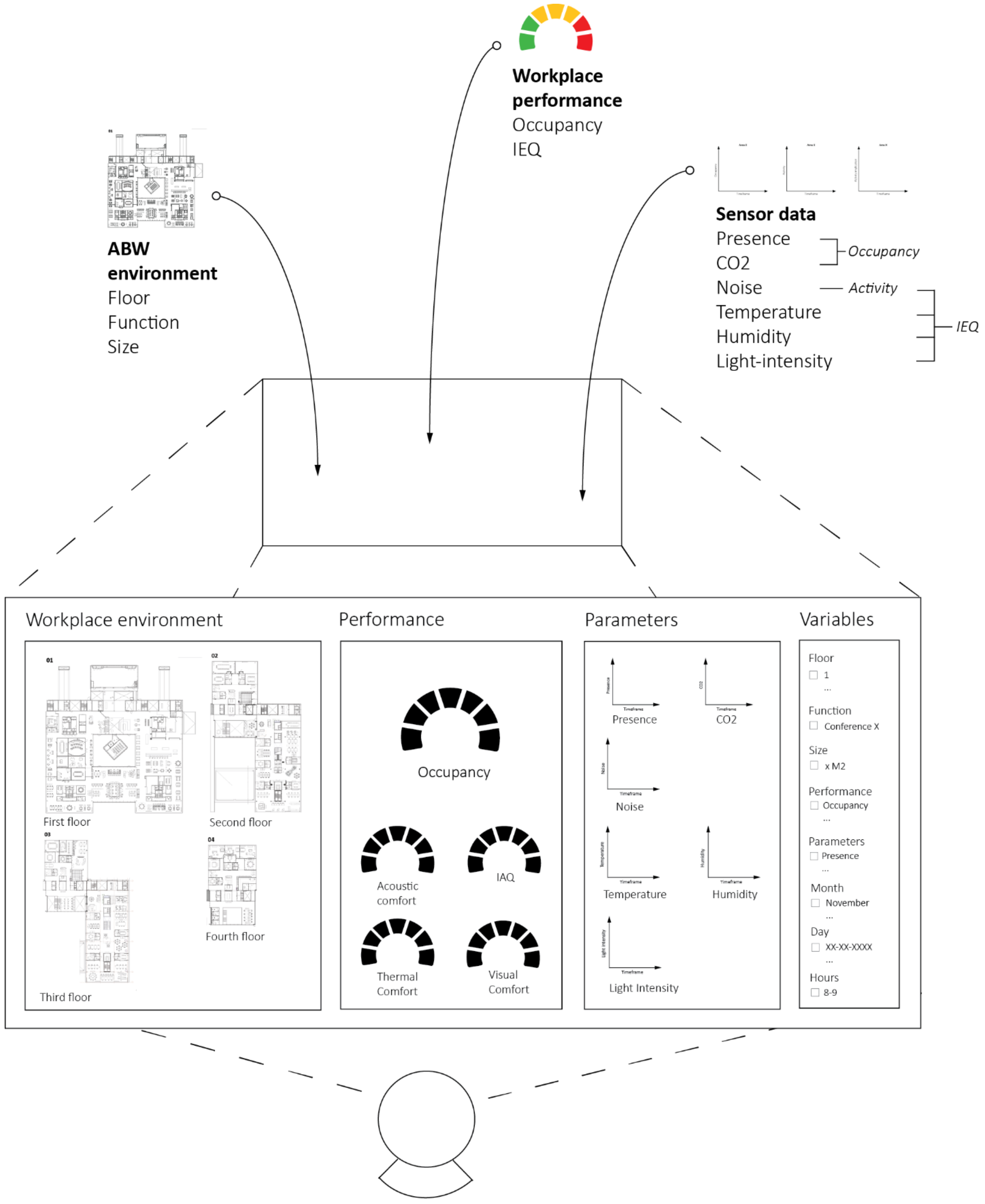
Emperical research

Measurement	Value
Temperature	Degree Celsius
Humidity	Percentage Humidity
Light intensity	Lux
CO2	Parts Per Million (PPM)
Movement	Pulse per minute
Noise level	Millivolt (MV)
Presence	0 = “available” - 1 = “occupied”

Emperical research


WORKPLACE
PERFORMANCE
IEQ
Occupancy
ACTIVITY IMPLICATION
Area X
CO2
Timeframe
Area X
Noise level
Timeframe
Area X
Temperature
Timeframe
Area X
Humidity
Timeframe
Area X
Light intensity
Timeframe
ACTIVITY
Area X
Noise level
Timeframe
OCCUPATION
Area X
Presence
Timeframe
Area X
CO2
Timeframe
OCCUPANTS

Emperical research



ABW environment
Floor
Function
Size

Workplace performance
Occupancy
IEQ

Sensor data
Presence ┐
CO2 ┘ *Occupancy*
Noise — *Activity*
Temperature ┐
Humidity │ *IEQ*
Light-intensity ┘

Workplace environment

First floor
Second floor
Third floor
Fourth floor

Performance

Occupancy
Acoustic comfort
IAQ
Thermal Comfort
Visual Comfort

Parameters

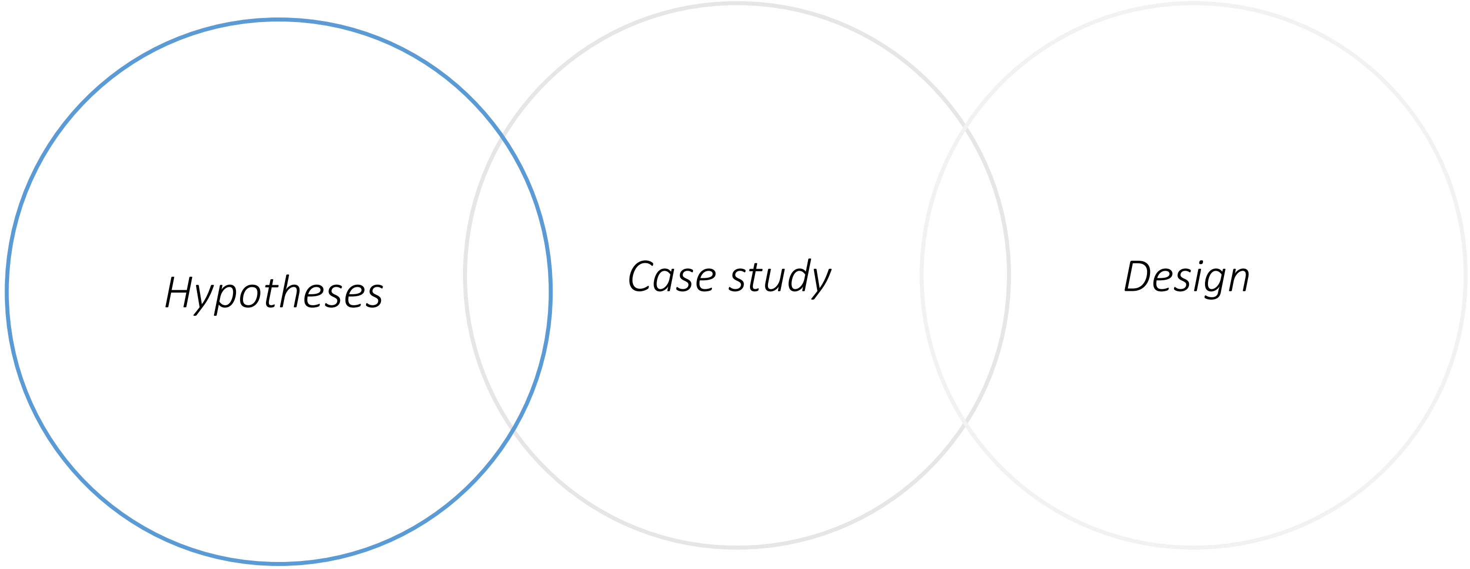
Presence
CO2
Noise
Temperature
Humidity
Light Intensity

Variables

Floor
☐ 1
…
Function
☐ Conference X
Size
☐ x M2
Performance
☐ Occupancy
…
Parameters
☐ Presence
…
Month
☐ November
…
Day
☐ XX-XX-XXXX
…
Hours
☐ 8-9

Facility manager

Emperical research


Hypotheses
Case study
Design

Emperical research

1

Acoustic privacy

The open workstations within the silent zones of the ABW environment have higher noise levels than the semi-closed workstations.

2

Space usage – organization

Based on the management and organization style, the conference rooms are relatively well utilized.

3

Space usage – location

The higher the floor level, the lower the occupancy rate of the conference rooms.

Emperical research

1

Acoustic privacy

The open workstations within the silent zones of the ABW environment have higher noise levels than the semi-closed workstations.

2

Space usage – organization

Based on the management and organization, the conference rooms are relatively well utilized.

3

Space usage – location

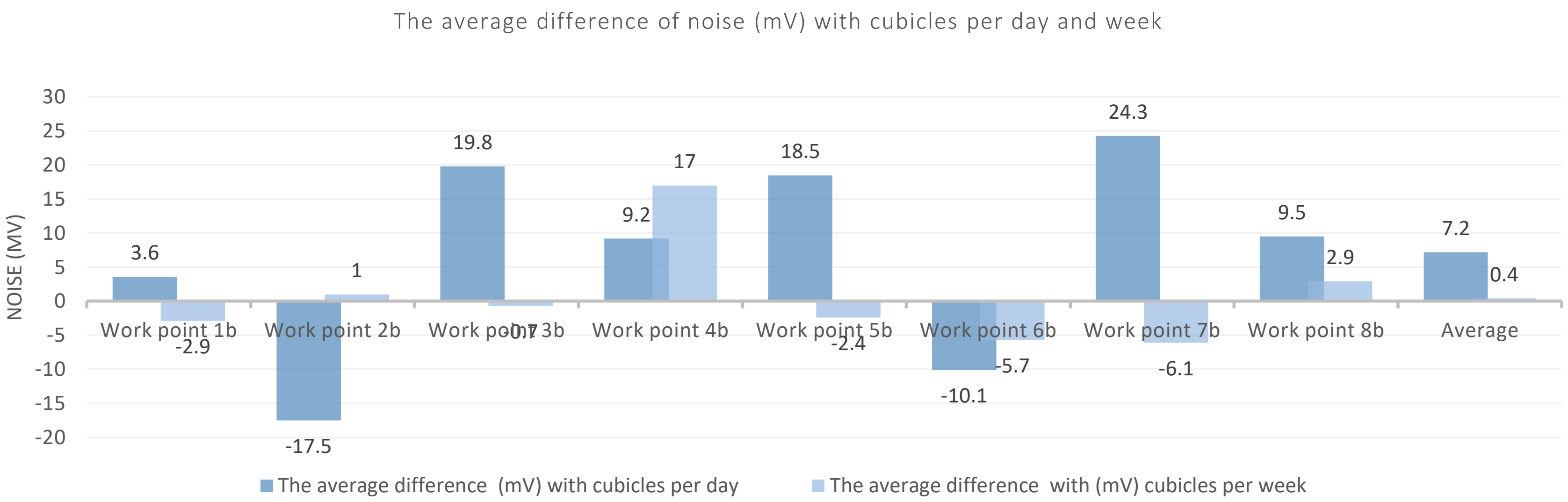
The higher the floor level, the lower the occupancy of the conference rooms.

Emperical research

- ABW environment
  - Two workstations within the silent zone.
- Performance
  - IEQ (acoustic comfort)
- Parameter
  - Noise, presence
- Variables
  - Floor: 3rd
  - Function: open and semi-closed workstation
  - Size: m2
  - Performance: acoustic comfort
  - Parameter: noise, presence
  - Month: January
  - Day: 13-01-2020 – 17-01-2020
  - Hours: 8:00 AM – 6:00 PM

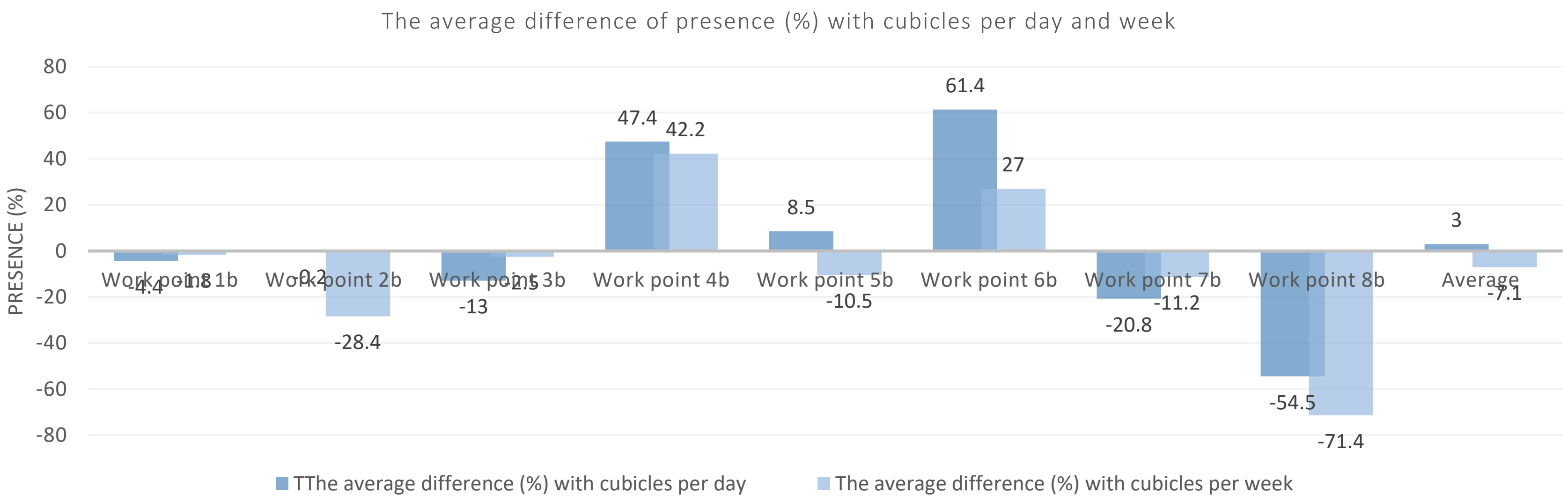
Emperical research

Noise level



Emperical research

Occupancy rate



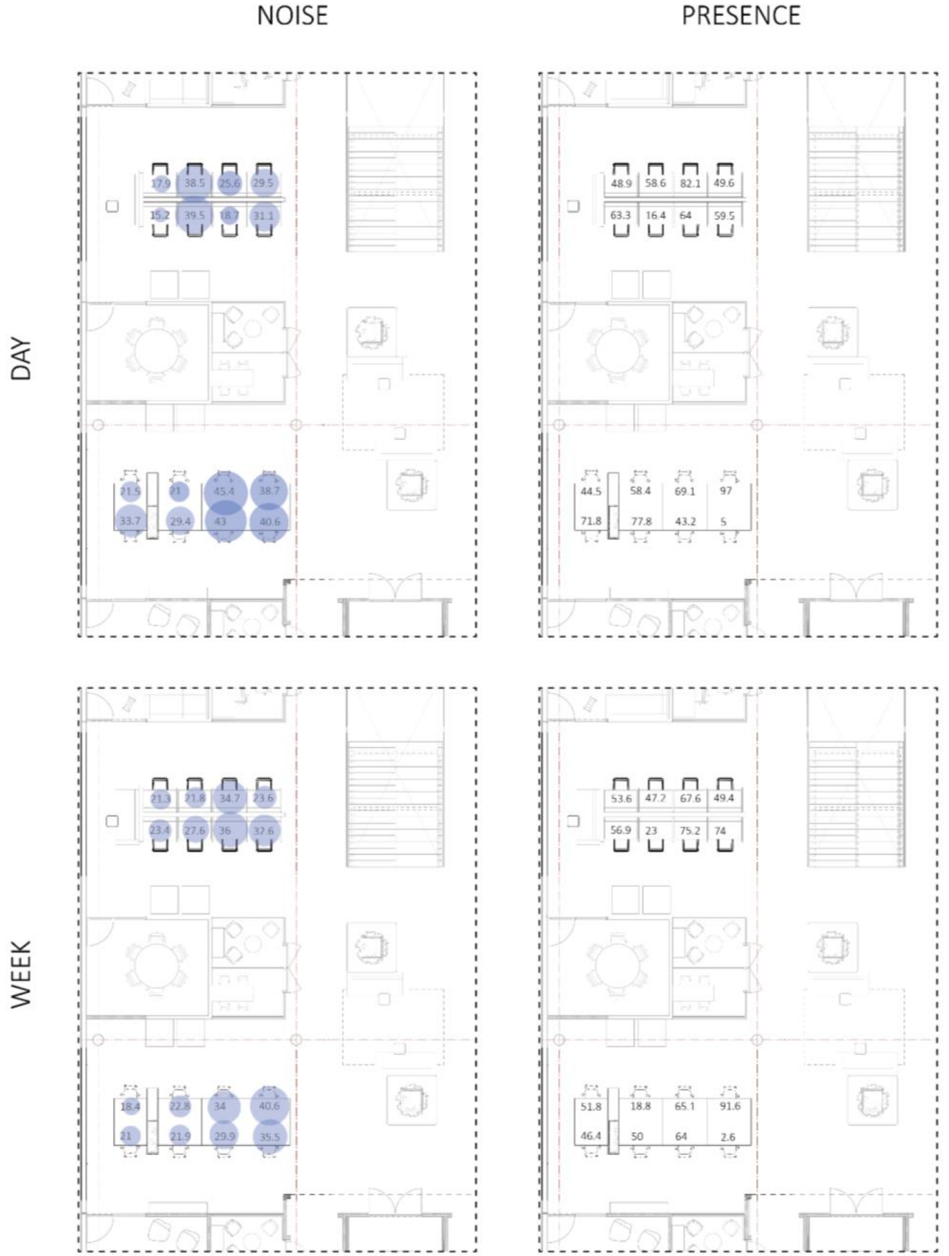
Emperical research

Noise level

Average noise levels day	↑	7.2 mV
Average noise levels week	↑	0.4 mV

Occupancy rate

Average occupancy rate day	↑	3 %
Average occupancy rate week	↓	7.1 %



NOISE
PRESENCE
DAY
WEEK
17.9
38.5
25.6
29.5
15.2
39.5
18.7
31.1
21.5
21
45.4
38.7
33.7
29.4
43
40.6
48.9
58.6
82.1
49.6
63.3
16.4
64
59.5
44.5
58.4
69.1
97
71.8
77.8
43.2
5
21.3
21.8
34.7
23.6
23.4
27.6
36
32.6
18.4
22.8
34
40.6
21
21.9
29.9
35.5
53.6
47.2
67.6
49.4
56.9
23
75.2
74
51.8
18.8
65.1
91.6
46.4
50
64
2.6

Emperical research

1

Acoustic privacy

The open workstations within the silent zones of the ABW environment have higher noise levels than the semi-closed workstations.

2

Space usage – organization

Based on the management and organization style of Microsoft, the conference rooms are relatively well utilized.

3

Space usage – location

The higher the floor level, the lower the occupancy of the conference rooms.

Emperical research

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Based on the management and organization style of Microsoft, the conference rooms are relatively well utilized.

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Space usage – location

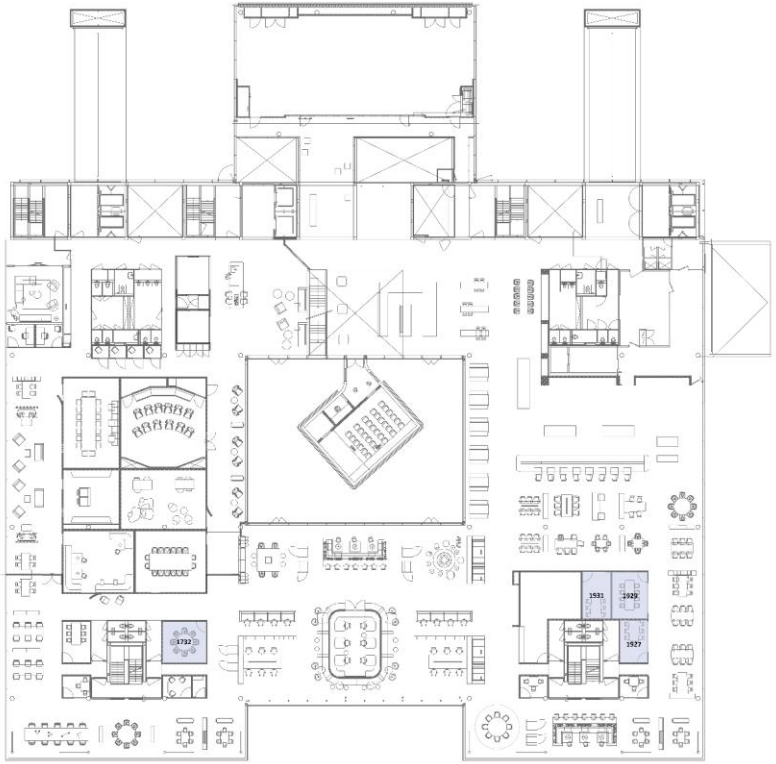
The higher the floor level, the lower the occupancy of the conference rooms.

Emperical research

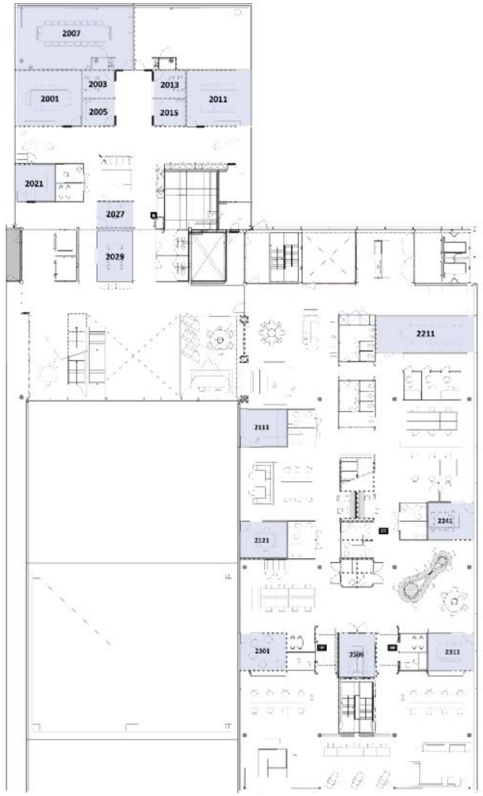
- ABW environment
  - There is a total of 43 conference rooms identified.
- Performance
  - Occupancy (space utilization)
- Parameter
  - Presence and CO2
- Variables
  - Floor: 1st, 2nd, 3rd, and 4th
  - Function: conference room
  - Size: m2
  - Performance: occupancy
  - Parameter: presence, CO2
  - Month: November
  - Day: 11-11-2019 – 15-11-2019
  - Hours: 8:00 AM – 6:00 PM

Emperical research

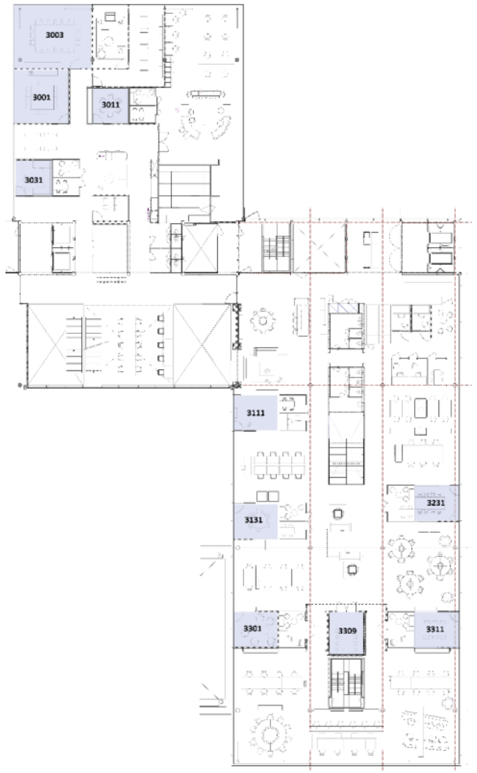
01


1931
1929
1927
1732

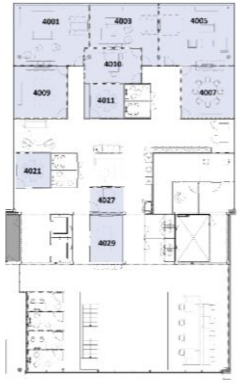
02


2007
2003
2001
2005
2013
2015
2011
2021
2027
2029
2211
2111
2241
2121
2301
2309
2311

03


3003
3001
3011
3031
3111
3231
3131
3301
3309
3311

04


4001
4003
4005
4010
4009
4011
4007
4021
4027
4029

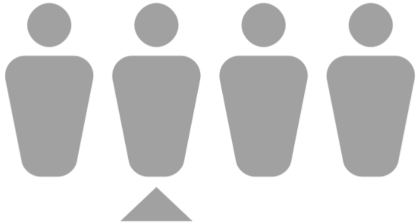
🟦 Conference room

0000 Location ID

Emperical research

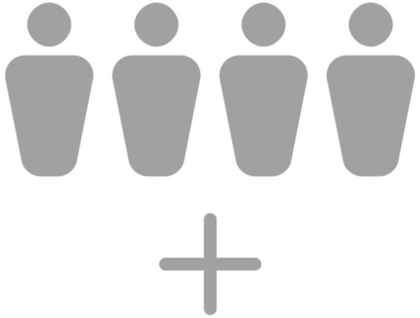
Presence (%)

At least one person in the room



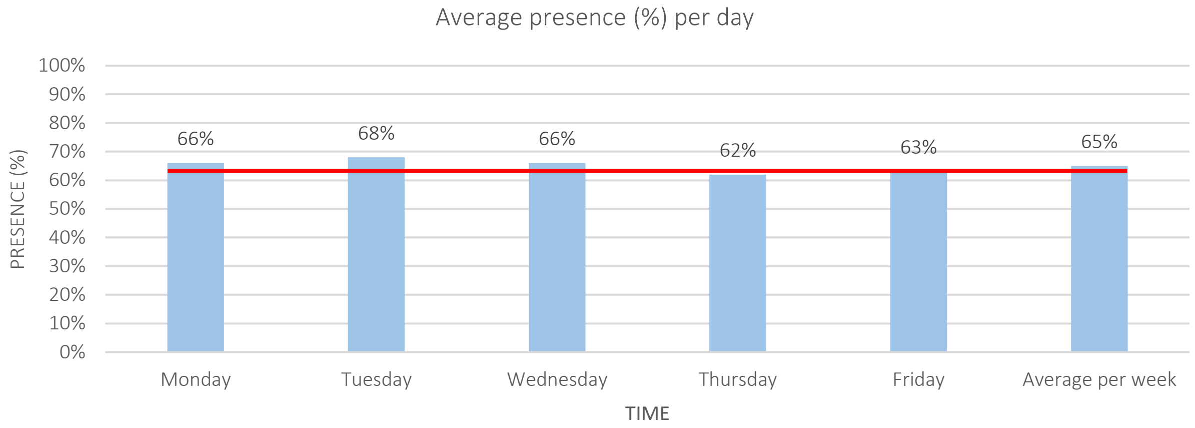
CO2 >1000 PPM

Spaces are used more intensely than predicted

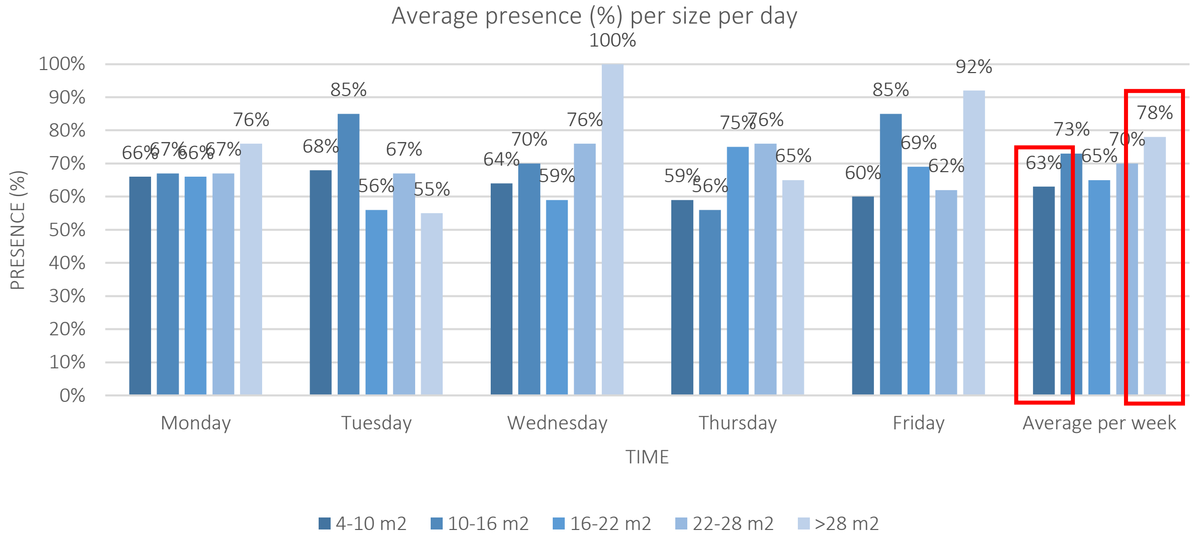


Emperical research

Presence (%)
per day

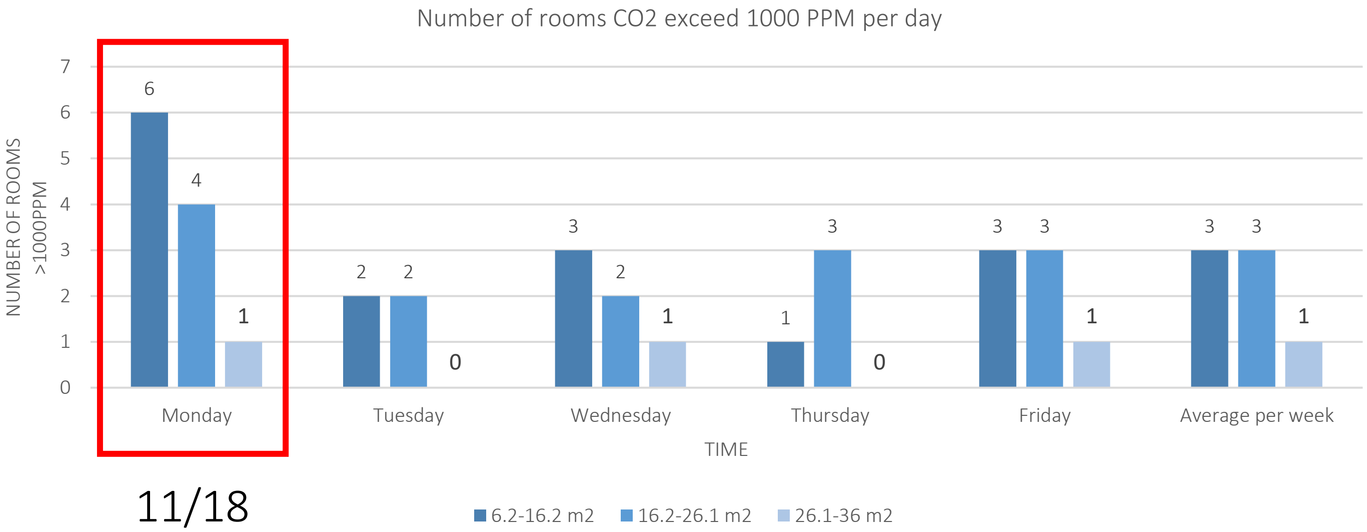


Presence (%)
per day per size



Emperical research

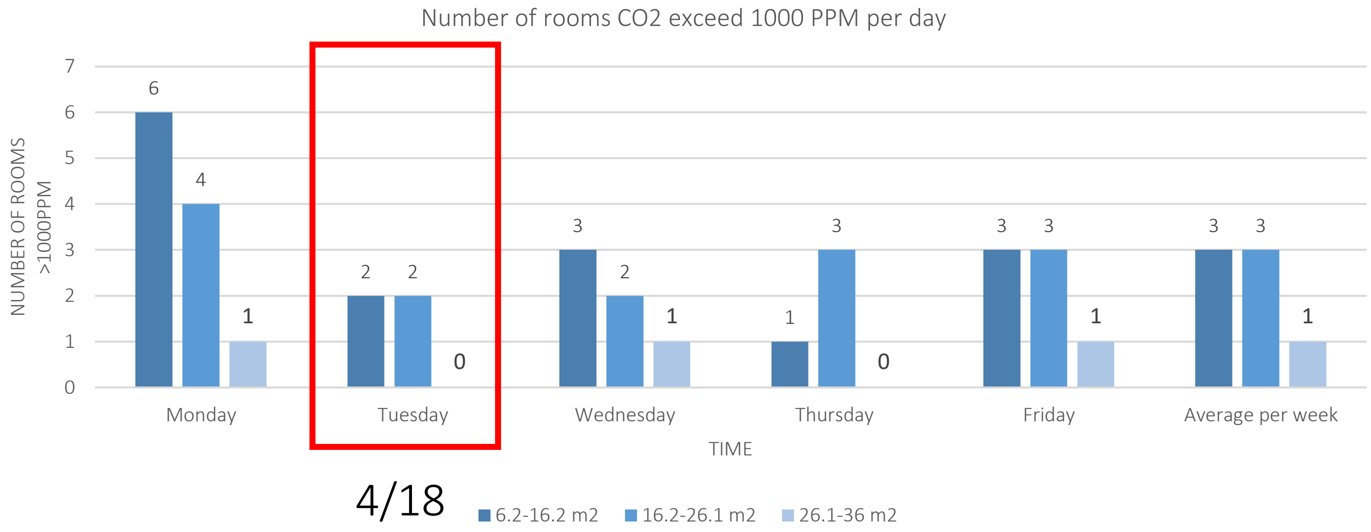
CO2 >1000 PPM
per day per size



11/18

Emperical research

CO2 (%)
per day per size



4/18

Emperical research

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- Performance
  - Occupancy (space utilization)

- Parameter
  - Presence and CO2

- Variables
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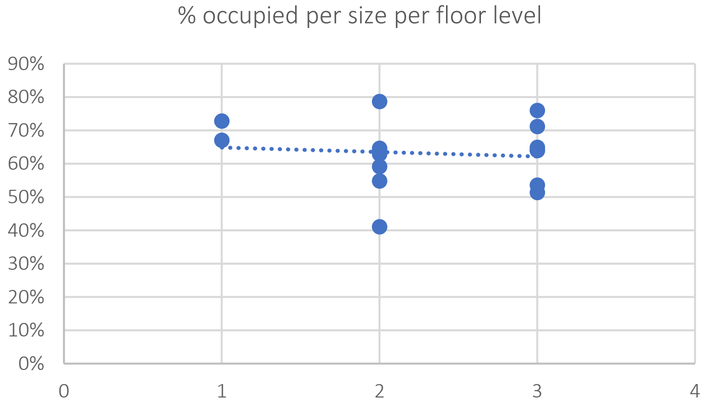
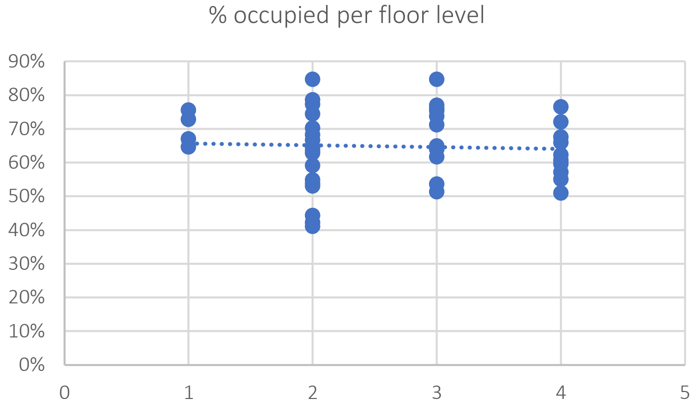
  - Hours: 8:00 AM – 6:00 PM

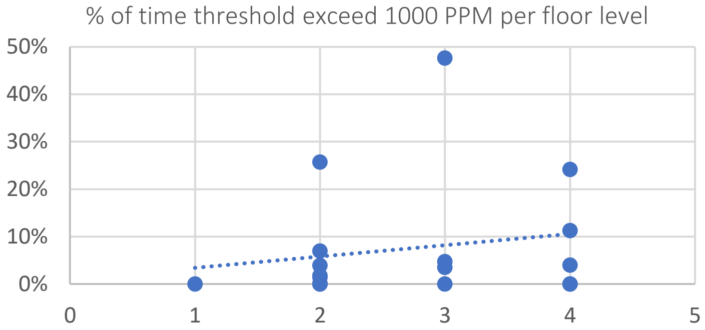
Emperical research

Presence (%)





CO2 (%)



Emperical research

AVERAGE (%) PRESENCE

10	FOURTH FLOOR	63%
12	THIRD FLOOR	68%
17	SECOND FLOOR	62%
4	FIRST FLOOR	70%
	ENTRANCE	

AVERAGE (%) CO2 >1000PPM

5	FOURTH FLOOR	8%
8	THIRD FLOOR	14%
4	SECOND FLOOR	5%
1	FIRST FLOOR	0%
	ENTRANCE	

Emperical research

1

Acoustic privacy

The open workstations within the silent zones of the ABW environment have higher noise levels than the semi-closed workstations.

2

Space usage – organization

Based on the management and organization style, the conference rooms are relatively well utilized.

3

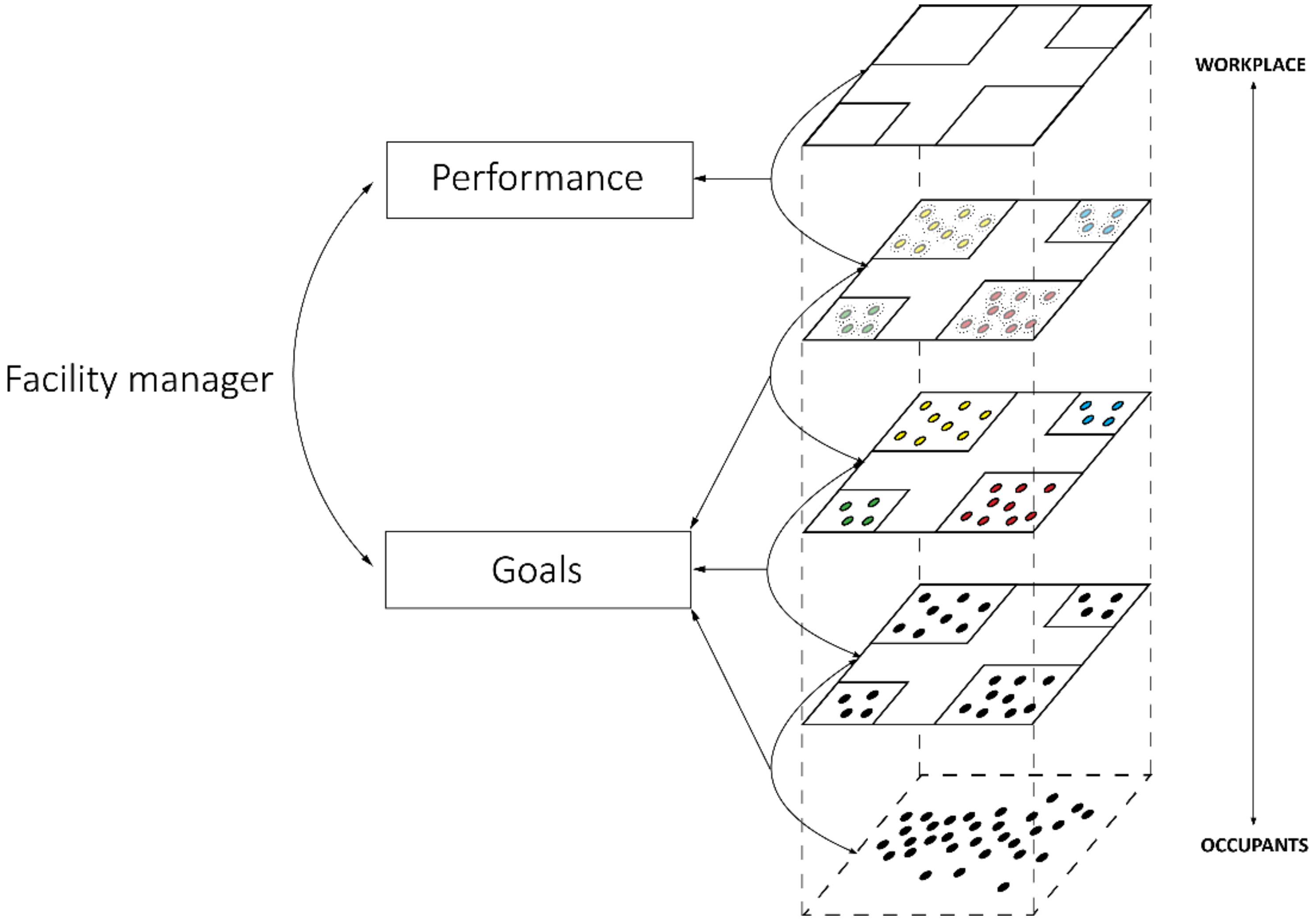
Space usage – location

The higher the floor level, the lower the occupancy of the conference rooms.

Findings and discussion

Organization of an ABW environment

Findings and discussion



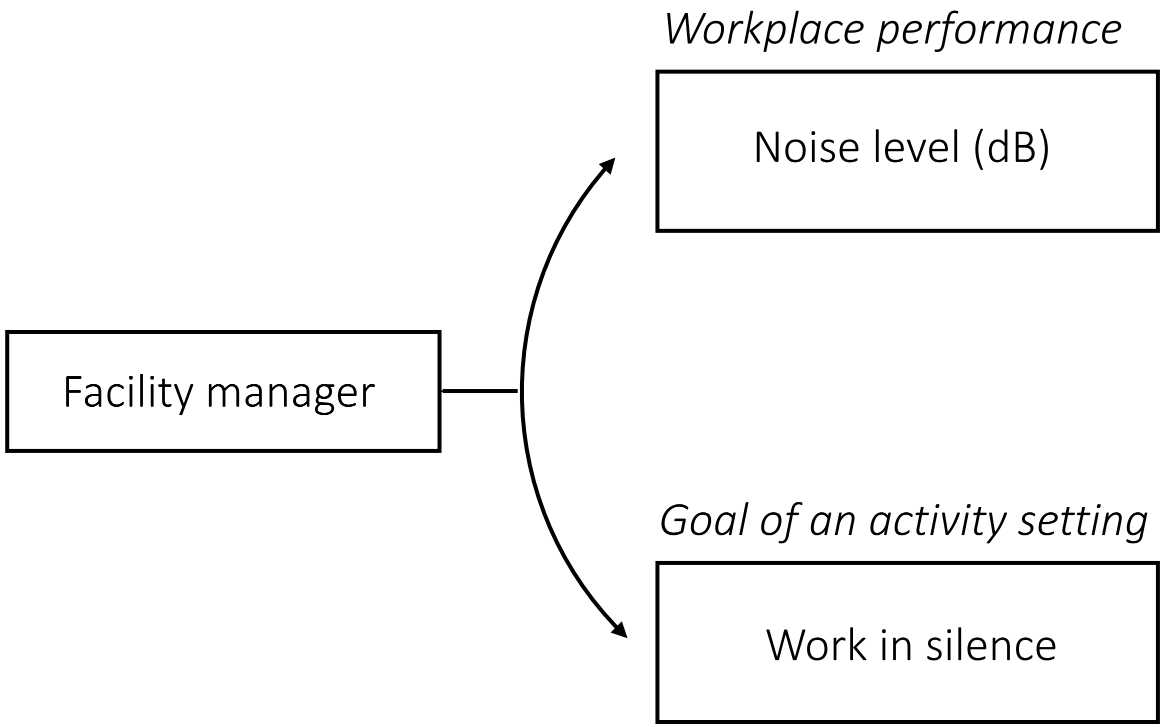
Performance

Facility manager

Goals

WORKPLACE
OCCUPANTS

Findings and discussion



Facility manager

Workplace performance

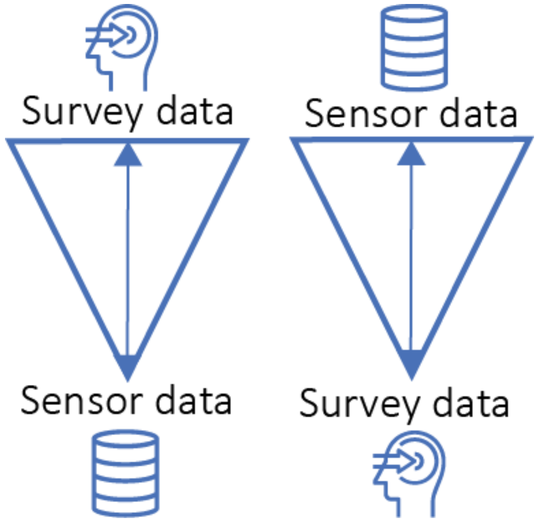
Noise level (dB)

Goal of an activity setting

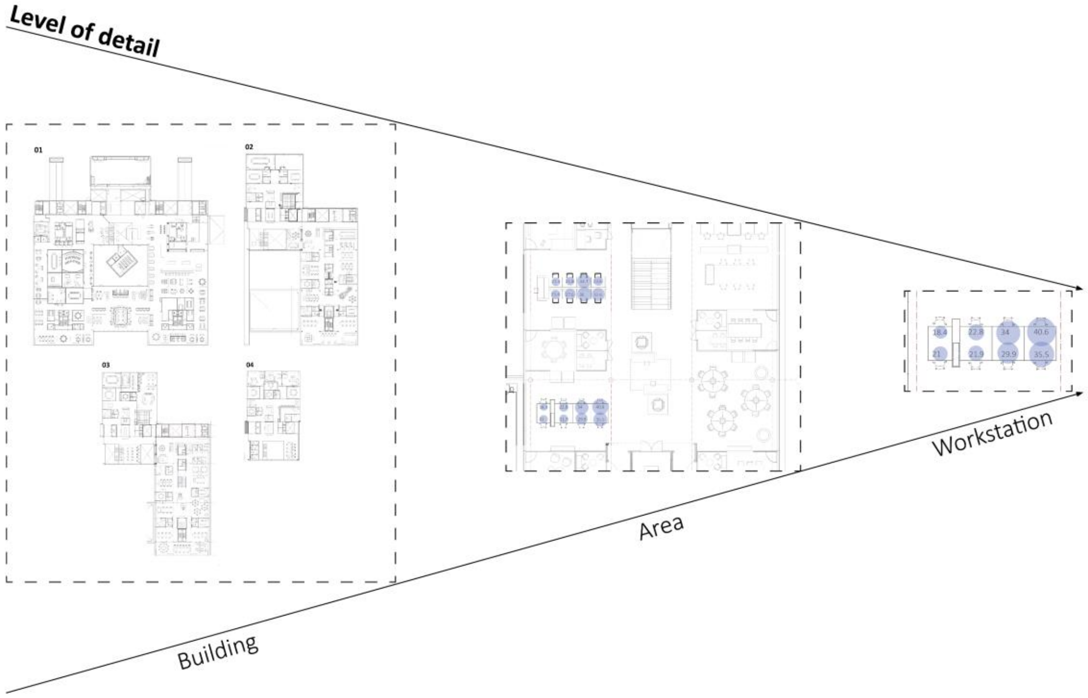
Work in silence

Qualitative and quantitative observations

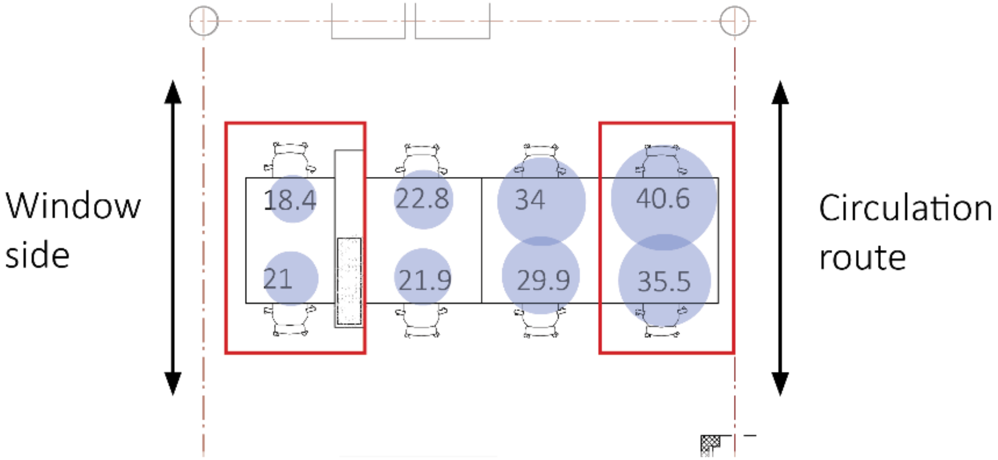
Findings and discussion


Survey data
Sensor data
Sensor data
Survey data

Findings and discussion

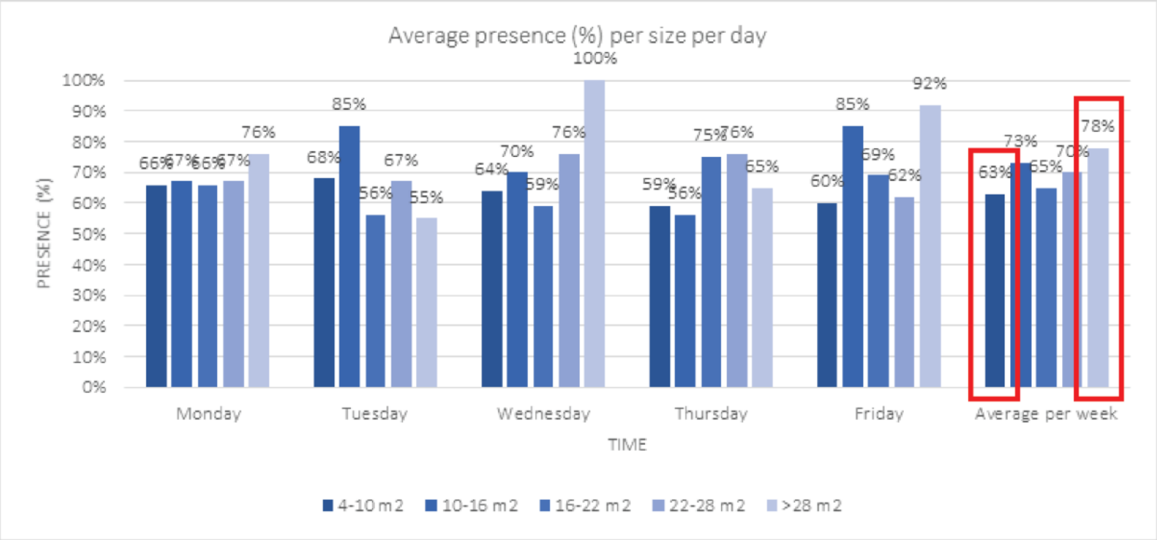

Level of detail
01
02
03
04
18.4
22.8
34
40.6
21
21.9
29.9
35.5
Building
Area
Workstation

Findings and discussion

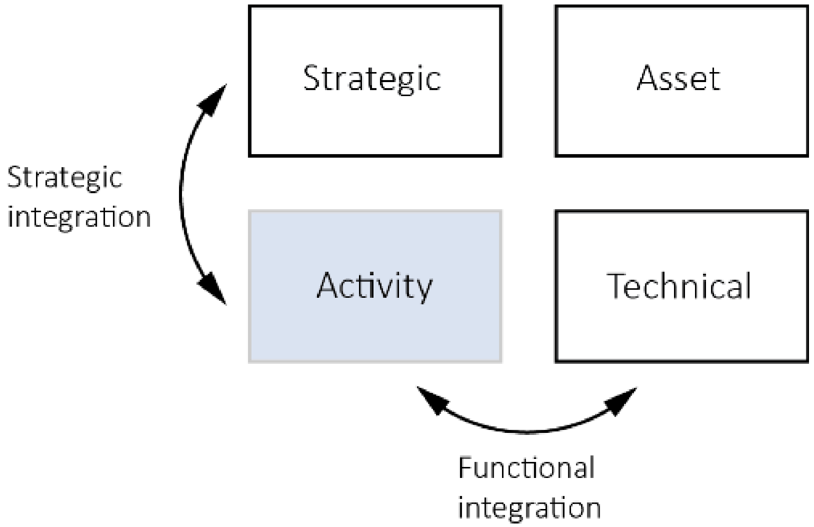

Window
side
18.4
22.8
34
40.6
21
21.9
29.9
35.5
Circulation
route

Operational to strategic management

Findings and discussion



Findings and discussion



Strategic

Asset

Activity

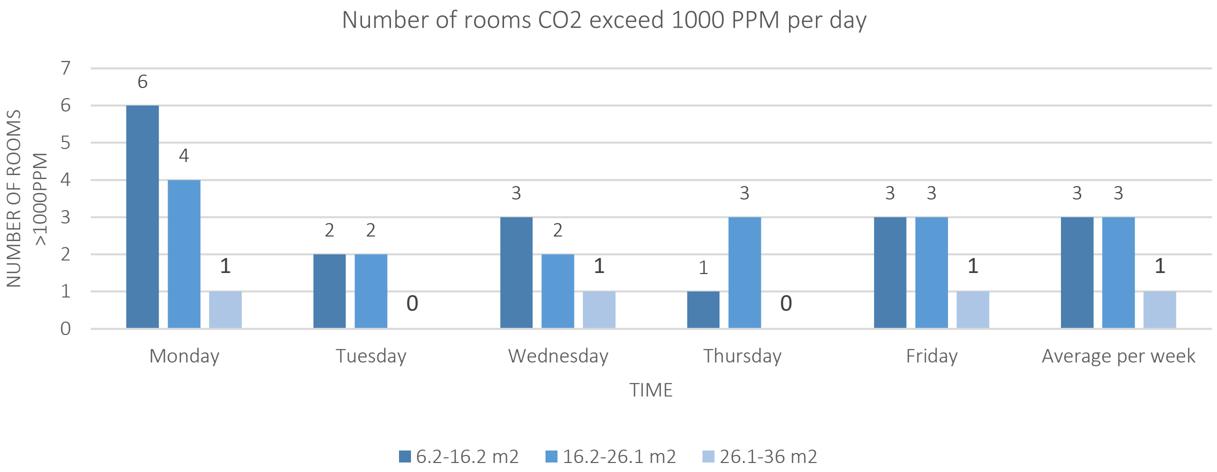
Technical

Strategic integration

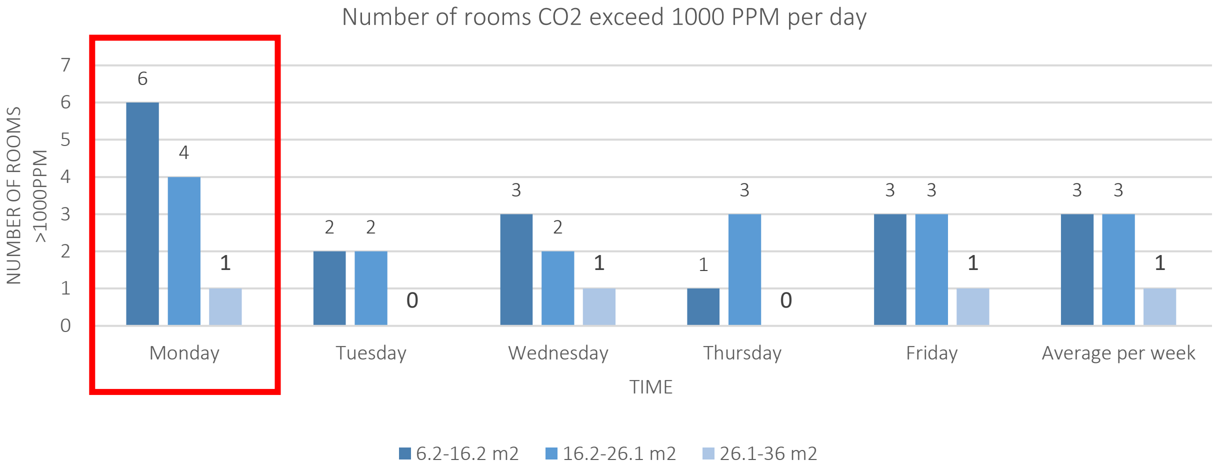
Functional integration

Indoor Air Quality (IAQ)

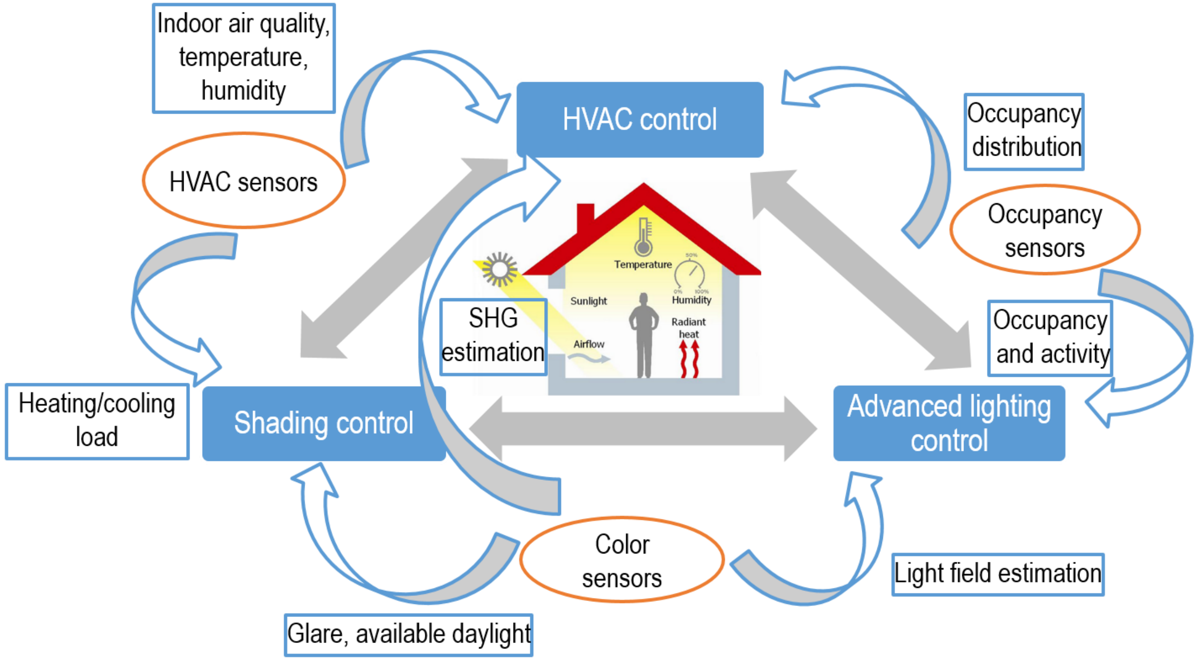
Findings and discussion



Findings and discussion



Findings and discussion


Indoor air quality, temperature, humidity
HVAC control
Occupancy distribution
HVAC sensors
Occupancy sensors
Temperature
Sunlight
Humidity
Radiant heat
Airflow
SHG estimation
Occupancy and activity
Heating/cooling load
Shading control
Advanced lighting control
Color sensors
Light field estimation
Glare, available daylight

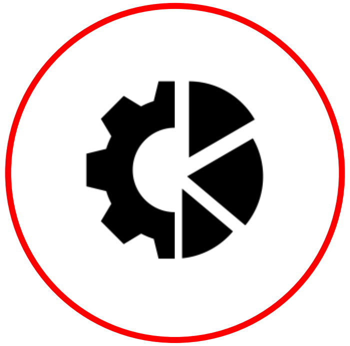
Source: Isaac, n.d.

Limitations

Findings and discussion

Availability

Findings and discussion



Functionality

Findings and discussion

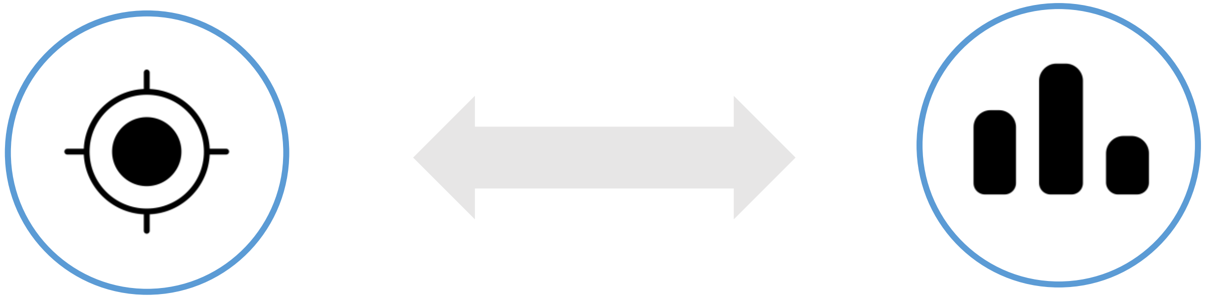
Management

Findings and discussion

Meaning

Conclusion

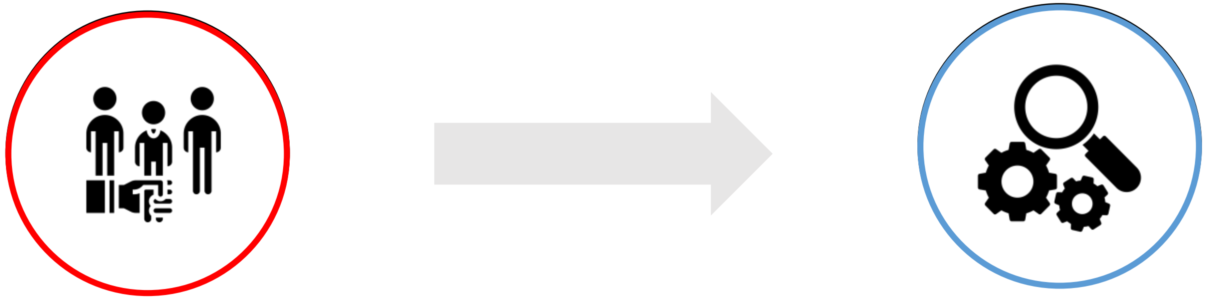
Conclusion



Goals

Performance

Conclusion



Reactive

Proactive

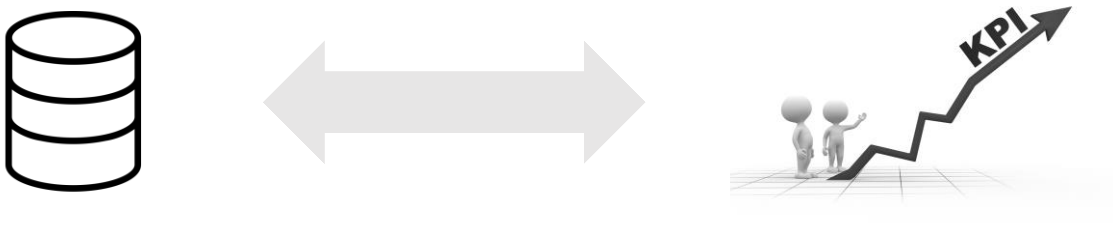
Conclusion

Smart buildings

Conclusion

Functionality

Conclusion



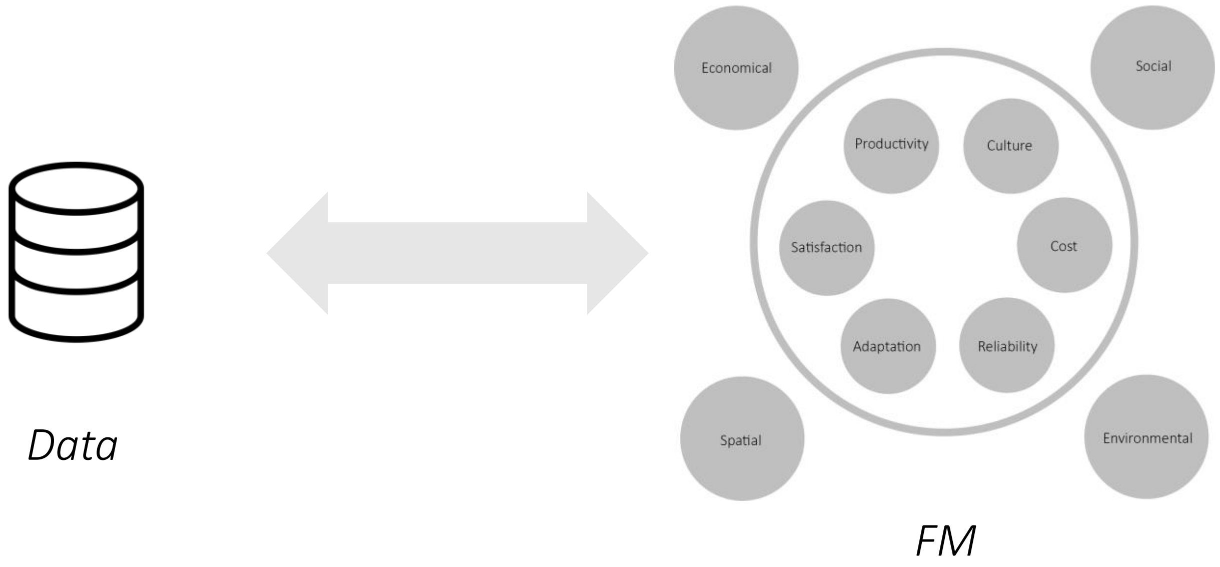
Data

KPIs

Conclusion

Benchmarking

Conclusion



Data

Economical

Social

Productivity

Culture

Satisfaction

Cost

Adaptation

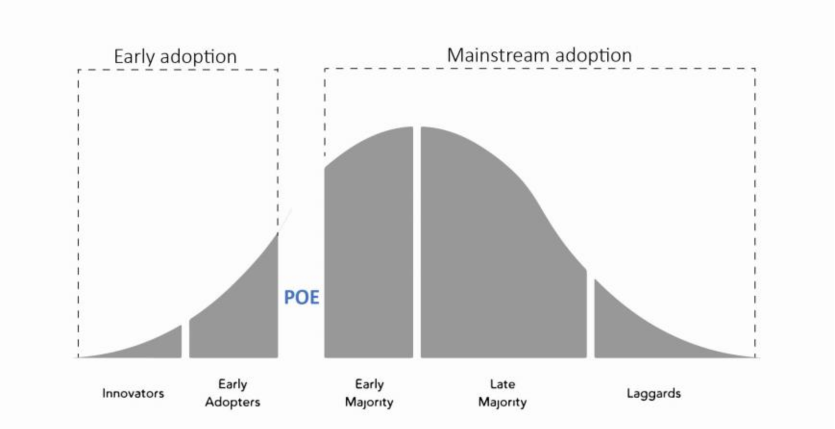
Reliability

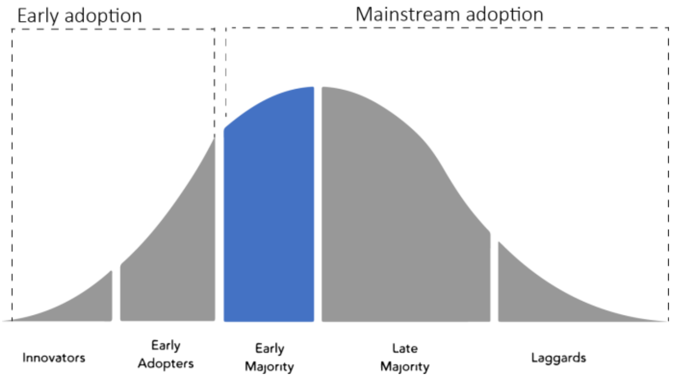
Spatial

Environmental

FM

Conclusion


Early adoption
Mainstream adoption
POE
Innovators
Early Adopters
Early Majority
Late Majority
Laggards


Early adoption
Mainstream adoption
Innovators
Early Adopters
Early Majority
Late Majority
Laggards