



CIB Facilities Management Conference 2014 | DTU

 POLITECNICO DI MILANO



#59 | A rating system for building condition ranking

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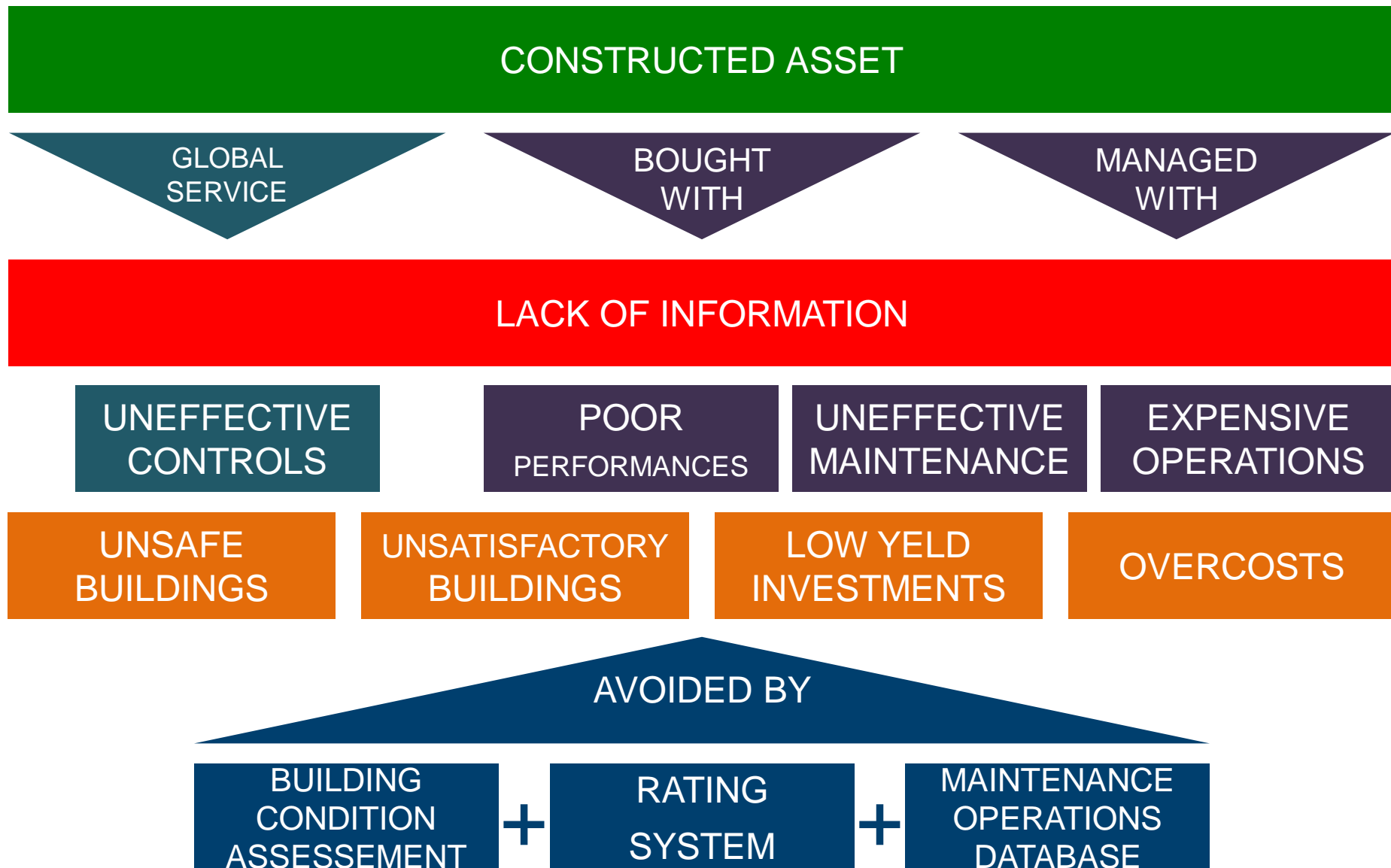
sebastiano.maltese@polimi.it

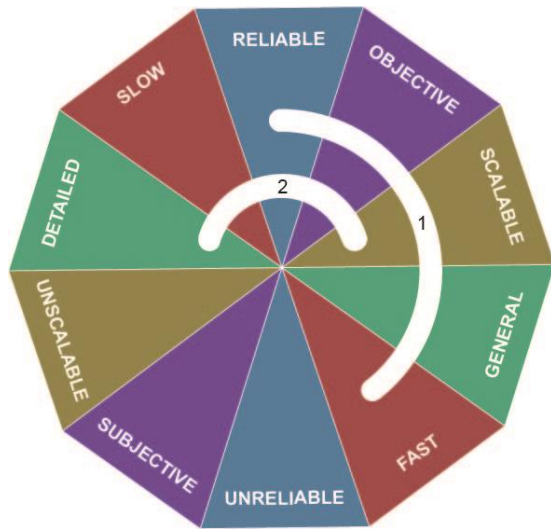
Building Condition and Evaluation | 22 May 2014 | 10.45 – 12.15



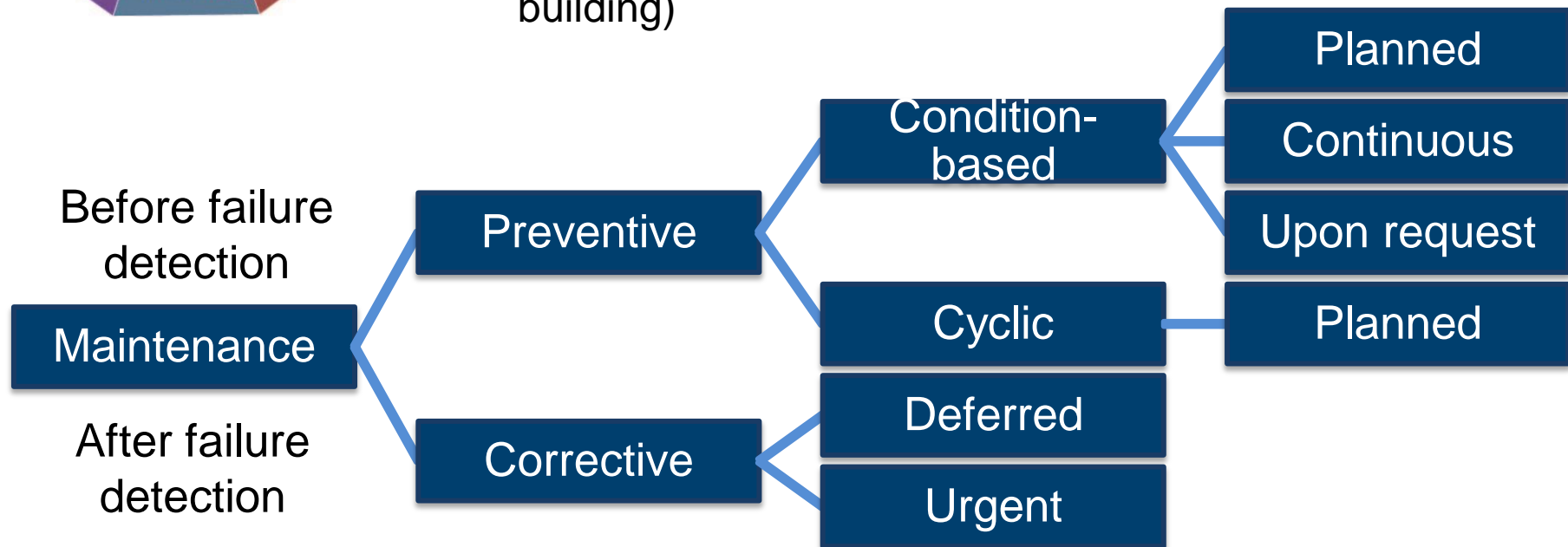
Do people know everything about their asset?

2





- Building Condition Assessment**
- tailored on building function
 - planned and not “fault-based”
 - associated with a rating
 - objective and reliable
 - scalable
1. quick and rough (e.g. for many buildings in an asset)
 2. slow and detailed (e.g. more deteriorated components in a specific building)





WBS and diagnostic forms

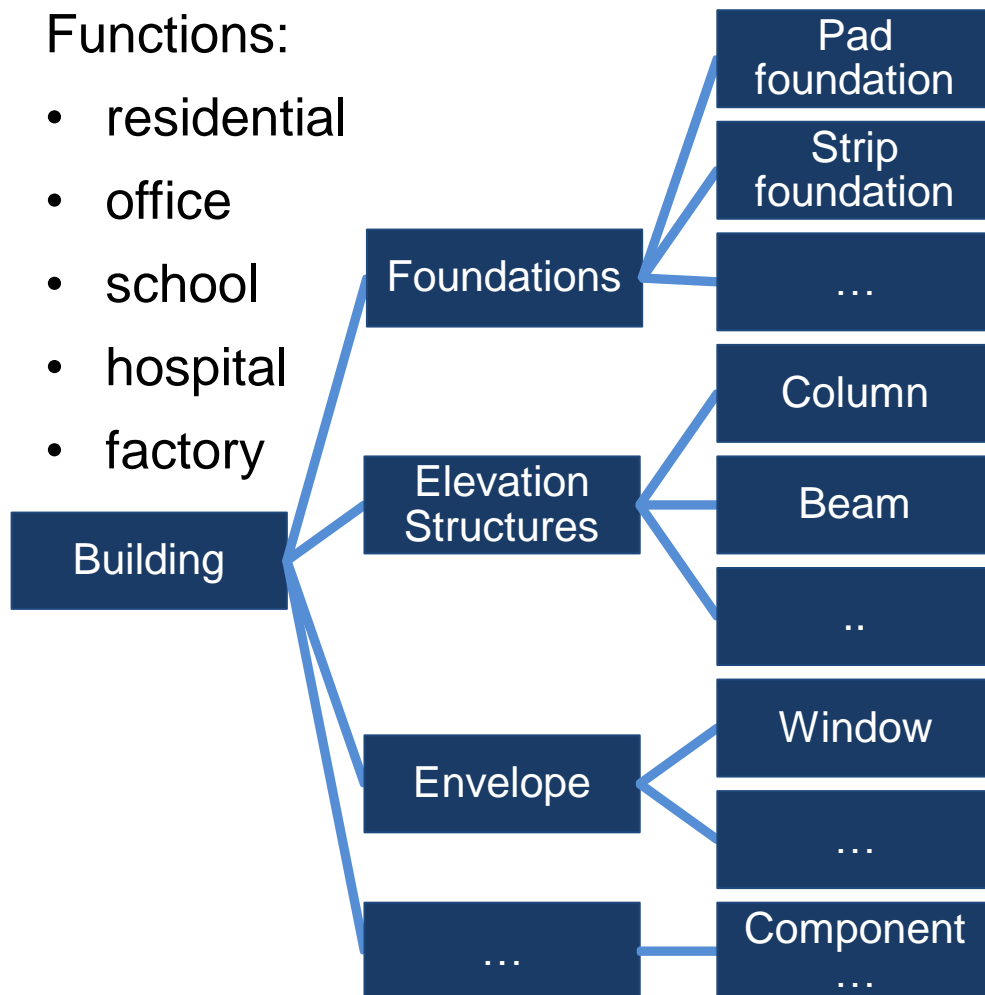
4

Functions:

- residential
- office
- school
- hospital
- factory

Technological units

Components



FORM DATA		COMPONENT DATA		
FORM NUMBER	01	COMPONENT	EPL01	
CODE	C.V.01.01.03.01-EPL01-S1	TECHNICAL ELEMENT CLASS	C.V.01	
NAME	FORM-External Plaster	TECHNICAL ELEMENT	C.V.01.01	
		TYPOLOGY	C.V.01.01.03	
		MATERIALE	C.V.01.01.03.01	
		ASL (Actual Service Life)	Plaster Masonry	
SERVICE LIFE INDEX		ASL	D+= 28	
DEGRADATION INDEX		D+=	0.893	
		D-=		
		A _C =	#VALORE!	
		A _{Cmax} =		
		A _{Cmin} =		
ANOMALIES				
TYPOLOGY	NAME	DESCRIPTION	EVALUATION PARAMETERS	
		PRESENCE [Y/N]	TO BE EVALUATED EXTENSION	
MINORS	Color change	Sottile trama di fessure sulla superficie, lesioni capillari, eventuali interpenetrazioni dell'elemento.	Y	Visibility and iteration, hanging and the brightness color.
	Superficial deposits	Attacco a parte di funghi, alghe, muschi, piante insetti e conseguente formazione di macchie e depositi superficiali.	N	Nature, consistence and visibility of the deposits.
	Efflorescence of parts structural	Formazioni cristalline solubili sulla superficie, generalmente di colore biancastro.	Y	Visibility, phenomenon, spore and the efflorescence.
	Alteration of finish	Bollature, screpolature, sfogliamento e sfarinamento dello strato di rivestimento pitture.		
MEDIUM	Croste	Attacco spontaneo.	Y	
	Erosion of finish	Fenomeno di natura.		
	Microfessure	Fenomeno di natura.		
	Attacco all'intonaco	Fenomeno di natura.		
GRAVI	Degradation of the intaco	Fenomeno di natura.		
	Distacco di intaco	Fenomeno di natura.		
	Rigonfiamento	Fenomeno di natura.		

1 Form data
name, number, code, ...

2 Component data
name, WBS link, description, ...

3 Anomalies assessment
type, presence/absence, extension

4 Service life index
D⁺_C or D⁻_C, depending on ASL

5 Degradation index
A_C average of the existing anomalies



BUILDING CONDITION INDEX

TECHNICAL INDEX

SERVICE LIFE
INDEX (D⁺, D⁻)

DEGRADATION
INDEX (A)

DOCUMENTS
INDEX

MAINTENANCE OPERATIONS

URGENT

DEFERRED

DOCUMENTS
UPDATE



TECHNICAL INDEX

SERVICE LIFE
INDEX

DEGRADATION
INDEX

D⁺

D⁻

A

Service Life index:
ratio between ASL
and RSL (D⁺ and D⁻)

Degradation index:
ratio between
anomalies found and
possible (A)

Database with:

- **18** technological units
- **>400** components (organised in a **WBS**)
- **431** anomalies (low, medium, serious)
- ~12 anomalies for each component
- **RSL** associated to each component (from literature)



COMPONENTS

Ext. plaster

Windows

Heating sys.

Paint

Flooring

Lift

Balconies

...

D⁺

D⁻

A

$$D_C^+ = \frac{RSL - ASL}{RSL} \text{ if } ASL \leq RSL \text{ or } D_C^- = 1 - \frac{ASL - RSL}{ASL} \text{ if } ASL > RSL$$

$$A_L = \frac{\sum_{i=1}^L P_{L,i} * E_i}{L}$$

$$A_M = \frac{\sum_{j=1}^M P_{M,j} * E_j}{M}$$

$$A_S = \frac{\sum_{k=1}^S P_{S,k} * E_k}{S}$$

$$A_C = \frac{A_L * W_L + A_M * W_M + A_S * W_S}{(W_L + W_M + W_S)}$$

Simple mean

TECHNOLOGICAL UNITS

Elevation
structures

Opaque
envelope

Transparent
envelope

...

Weighted mean

$$D_{Bld}^+ = \frac{\sum_{k=1}^o D_{TU,k}^+ * W_k^{E/C}}{\sum_{k=1}^o W_k^{E/C}}$$

$$D_{Bld}^- = \frac{\sum_{k=1}^o D_{TU,k}^+ * W_k^{E/C}}{\sum_{k=1}^o W_k^{E/C}}$$

$$A_{Bld} = \frac{\sum_{k=1}^o A_{TU,k} * W_k^{E/C}}{\sum_{k=1}^o W_k^{E/C}}$$

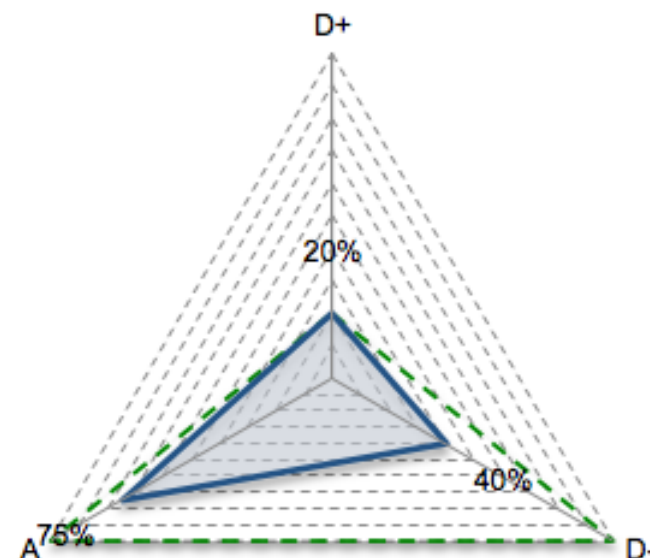
Tailored on function

BUILDING



TECHNOLOGICAL UNIT			WEIGHTS	WEIGHTED INDEXES			ANOMALIES	
#	CODE	NAME		# FORMS [-]	D ⁺	D ⁻	A	# A
01	S.F	Foundations						0 on 0
02	S.C	Retains structures						0 on 0
03	S.E	Elevation struvtures						0 on 0
04	C.V.O	Opaque envelope	5	20.41%	2.72%	13.27%	19.14%	22 on 90
05	C.V.T	Transparent envelope	8	12.12%	1.26%	6.06%	9.34%	44 on 105
06	C.O.I	Slab on ground	1	3.83%	0.00%	1.92%	3.52%	3 on 13
07	C.OSA	Slab on open spaces						0 on 0
08	C.S	Roof						0 on 0
09	PI.V	Inernal vertical partition	5	22.49%	0.00%	13.87%	17.97%	26 on 52
10	PI.O	Inernal horizontal partition	4	16.89%	0.00%	11.96%	16.47%	9 on 66
11	PE.V	External vertical partition	1	2.18%	0.00%	1.99%	1.77%	7 on 20
12	PE.O	External horizontal partition	2	4.77%	0.00%	2.18%	2.55%	17 on 27
13	IFS.IC	HVAC						0 on 0
14	IFS.IDS	Water and sanitary plant						0 on 0
15	IFS.E	Electric plant	4	13.58%	10.41%	13.58%	13.49%	3 on 22
16	IFS.SL	Sewer plant						0 on 0
17	IFS.TR	Lift plant	2	3.73%	0.00%	2.49%	3.45%	2 on 12
18	IFS.A	Fire plant						0 on 0
TOTAL			32	100.00%	14.39%	67.32%	87.70%	133 on 407

Technical Index 63.17%



$$I_{Tech} = \frac{Area_{Building}}{Area_{Optimal}} [\%]$$

- **blue line**: current building condition.
- **green dashed line**: optimal building condition.

D⁺ is equal in both cases because the building physiologically gets older, but this is not a failure.

- **133** on 407 possible **anomalies** detected
- **24** components with **ASL ≥ RSL**
- **8** components with **ASL < RSL**



DOCUMENTS INDEX

It is the weighted ratio between available and required documents.

A – Construction

B – Fire safety

C – Structures

D – Plants

E – Safety and O&M

F – Urban planning

G – Land register

H – As built

I – Origin and rights

- it relies on a list of documents required by Italian laws
- documents are grouped in 9 families (A to I) using a Documents Breakdown Structure
- each family has an importance weight (calculated with AHP technique)

It allows identification of documents:

- missing
- out of date
- non-compliant



SINGLE
DOCUMENT

NECESSIT
Y
[Y/N]



IMPORTANCE
[1→4]



QUANTITY
(if required)



PRESENC
E
[Y/N]

Ratio between present and required documents for each family

DOCUMENTS
FAMILIES

A
construction

B
fire safety

C
structures

...

Weighted sum of required documents families indexes

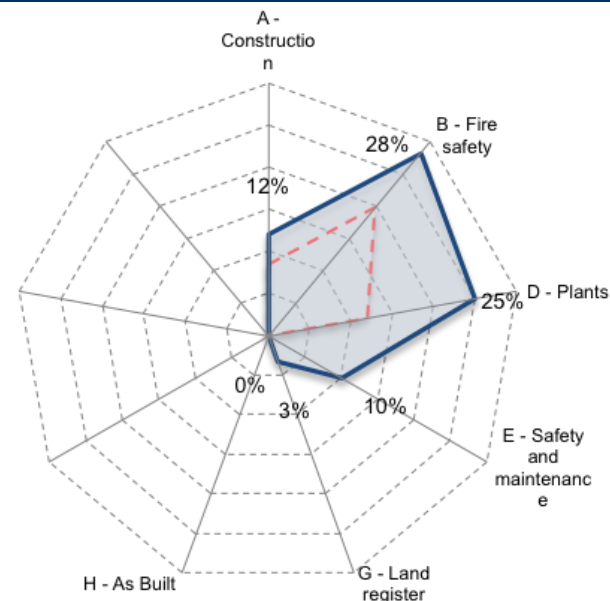
BUILDING
DOCUMENTS

$$I_{family} = S_{family} * W_{family} [\%]$$

$$I_{Doc} = \sum_{i=1}^N I_{family,i} [\%]$$



DOCS FAMILY		WEIGHT	FAMILY SCORE [%]	WEIGHTED SCORE [%]
A - Construction	✓	11.97%	100.00%	11.97%
B - Fire safety	✓	28.26%	100.00%	28.26%
C - Structures	✓			
D - Plants	✓	25.05%	100.00%	25.05%
E - Safety and maintenance	✓	10.19%	100.00%	10.19%
F - Urban planning	✓			
G - Land register	✓	3.27%	100.00%	3.27%
H - As built	✓	18.22%	0.00%	0.00%
I - Origins and rights	✓	3.05%	0.00%	0.00%

78.74%

- **blue line**: current documents available.
- **red dashed line**: level 1 documents – required by laws.
- an high rating does not mean a sufficient documents situation: each single family must be above sufficiency.
- some family may not be present because not relevant for the specific building.
- weights automatically calibrated on analysed docs families
- green/red check for mandatory documents



BUILDING CONDITION INDEX



Building index 71%

*average of previous indexes,
if both present.*

red: average of the below limits
yellow: average of the below limits



Technical index 63.17%

There are 38 serious anomalies on 32 diagnostic forms

red: “bad” condition
yellow: “normal” condition



Documents index 78.74%

Mandatory documents are all present

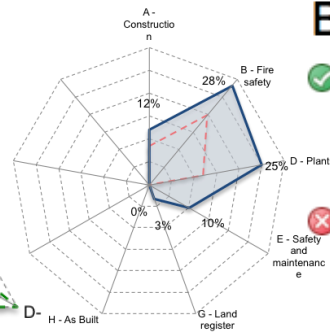
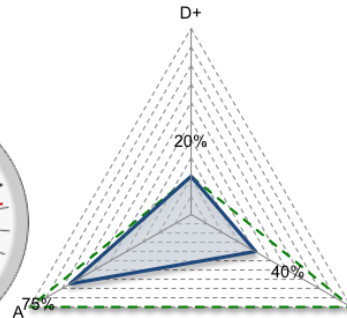
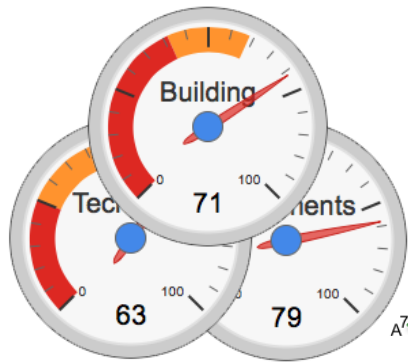
red: mandatory documents
yellow: zero



Building Condition Index

13

SYNTHETIC
VIEW



Building index 71%

✓ Documents index 78.74%
Mandatory documents are all present

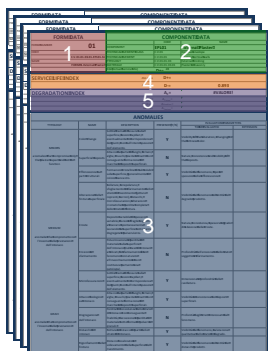
✗ Technical index 63.17%
There are 38 serious anomalies on 32 diagnostic forms

DETAILED
VIEW

TECHNOLOGICAL UNIT			WEIGHTS	WEIGHTED INDEXES			ANOMALIES	
#	CODE	NAME		# FORMS [-]	D*	D'		A
01	S.F	Foundations						0 on 0
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F - Urban planning	✓		
G - Land register	✓ 3.27%	100.00%	3.27%
H - As built	✓ 18.22%	0.00%	0.00%
I - Origins and rights	✓ 3.05%	0.00%	0.00%

COMPONENT
DATABASE



FAM. DOCS	DOCS	WEIGHT	SCORE	WEIGHTED SCORE
A1	Attestato di certificazione energetica	1	100%	1
A2	Attestato di certificazione energetica	1	100%	1
A3	Attestato di certificazione energetica	1	100%	1
A4	Attestato di certificazione energetica	1	100%	1
A5	Attestato di certificazione energetica	1	100%	1
A6	Attestato di certificazione energetica	1	100%	1
A7	Attestato di certificazione energetica	1	100%	1
A8	Attestato di certificazione energetica	1	100%	1
A9	Attestato di certificazione energetica	1	100%	1
A10	Attestato di certificazione energetica	1	100%	1
A11	Attestato di certificazione energetica	1	100%	1
A12	Attestato di certificazione energetica	1	100%	1
A13	Attestato di certificazione energetica	1	100%	1
A14	Attestato di certificazione energetica	1	100%	1
A15	Attestato di certificazione energetica	1	100%	1
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A82	Attestato di certificazione energetica	1	100%	1
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A87	Attestato di certificazione energetica	1	100%	1
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A92	Attestato di certificazione energetica	1	100%	1
A93	Attestato di certificazione energetica	1	100%	1
A94	Attestato di certificazione energetica	1	100%	1
A95	Attestato di certificazione energetica	1	100%	1
A96	Attestato di certificazione energetica	1	100%	1
A97	Attestato di certificazione energetica	1	100%	1
A98	Attestato di certificazione energetica	1	100%	1
A99	Attestato di certificazione energetica	1	100%	1
A100	Attestato di certificazione energetica	1	100%	1

- for different stakeholders and purposes
- incremental system
- to be used both for quick and detailed surveys
- good starting point for maintenance management and energy refurbishment



COMPONENTS ANOMALIES

Ext. plaster

Windows

Heating sys.

...

cracks

broken glass

water leakage

...

missing parts

dust

...

...

+ schedule + description

MAINTENANCE OPERATIONS

External plaster

cracks

missing parts

Dust

...

URGENT

restoration

partial replacement

cleaning

...

DEFERRED

partial replacement

complete replacement

...

...

- directly connected with components anomalies
- can be grouped together (opportunity maintenance)
- divided in macro-categories (restoration, cleaning, replacement, ...)
- best interventions to be done must be selected by the user
- associated with a schedule (short-medium-long term) and a description



Urgent maintenance operations

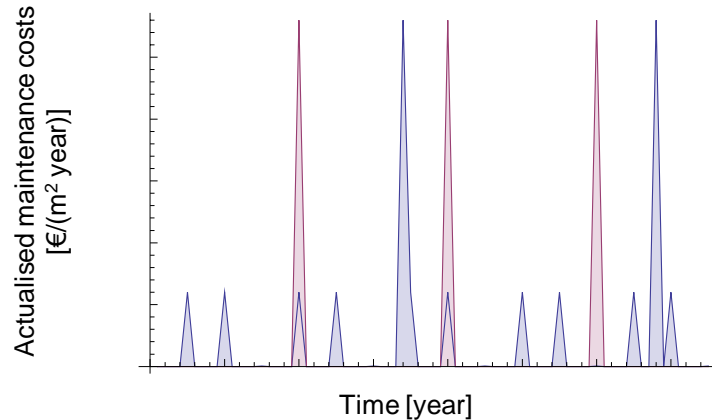
ANOMALY	OPERATION	SCHEDULE	DESCRIPTION
Finishing degradation	Restoration	long-term	Repainting and/or replacing hardware parts
Superficial deposits	Cleaning	long-term	Use of specific instruments and products
Hardware degradation	Restoration	middle-term	To be fixed, oiled and tuned
Gasket degradation	Partial replacement	middle-term	Disassembly and replacement
Biological attack	Restoration	short-term	Biological colony removal
Missing parts	Partial replacement	short-term	Disassembly and replacement

Extract of maintenance operations for a **wooden window**

Possibility to combine with other operations to be done on the main façade



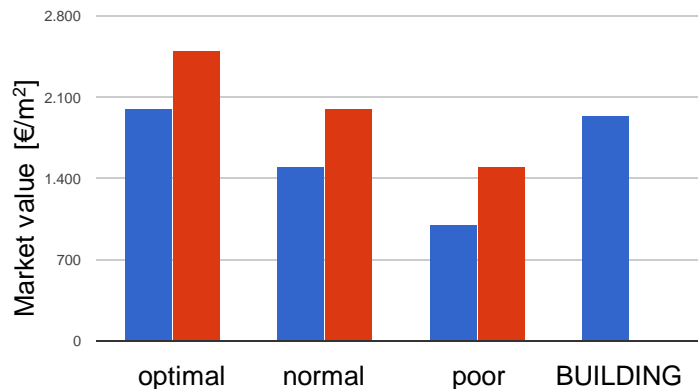
- complete maintenance profile for each component
- Life Cycle Cost for components maintenance profiles



External plaster LCC comparison

- planned maintenance (blue)
- corrective maintenance (red)

- Building Condition Indexes as an instrument to find the asset true market value



Evaluation of:

- asset market value
- maintenance cost to restore market value



The system helps in filling the lack of information for a constructed asset:

- it gives the **current building situation** (documents and degradation)
- It helps in the definition of **maintenance operations** to be done
- it is **incremental**
- it is **objective** and building **function** tailored
- it can be used both during **refurbishment** and **handover**
- its **reliability** has been tested with several case studies (made by different people's categories)
- it can be connected to a **quantity survey** and to **BIM** technologies